8 SOLID WASTE MANAGEMENT

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Solid waste management is one among the basic essential services provided by municipal authorities in the country to keep urban centres clean. However, it is among the most poorly rendered services in the basket—the systems applied are unscientific, outdated and inefficient; population coverage is low; and the poor are marginalized. Waste is littered all over leading to insanitary living conditions. Municipal laws governing the urban local bodies do not have adequate provisions to deal effectively with the ever-growing problem of solid waste management. With rapid urbanization, the situation is becoming critical. The urban population has grown fivefold in the last six decades with 285.35 million people living in urban areas as per the 2001 Census.

Quantum and Nature of Solid Waste

Per capita waste generation ranges between 0.2 kg and 0.6 kg per day in the Indian cities amounting to about 1.15 lakh MT of waste per day and 42 million MT annually. Also, as the city expands, average per capita waste generation increases (Tables 8.1 and 8.2).

Table 8.1
Waste Generation per Capita in Indian cities

Population range (in million)	Average per capita waste generation gms/ capita/ day
0.1 to 0.5	210
0.5 to 1.0	250
1.0 to 2.0	270
2.0 to 5.0	350
5.0 plus	500

Source: NEERI (1995)

Views expressed in the chapter are of the author.

Table 8.2
Waste Quantities and Waste Generation Rates in 1 million plus Cities and State Capitals

City	Waste quantity generated (MT/d)	Waste generation rate (kg/c/d/)
Vadodara*	157.33	0.12
Kohima	12.48	0.16
Nashik	200	0.19
Lucknow	474.59	0.21
Guwahati	166.25	0.21
Gandhinagar	43.62	0.225
Jabalpur	216.19	0.23
Ranchi	208.27	0.246
Nagpur	503.85	0.25
Dehradun	131	0.29
Raipur	184.27	0.3
Indore	556.51	0.35
Bhubaneshwar	234.46	0.36
Patna	510.94	0.37
Ahmedabad	1302	0.37
Faridabad	448.01	0.38
Dhanbad	77.12	0.387
Bangalore	1669	0.39
Bhopal	574.07	0.4
Agartala	77.36	0.4
Asansol	206.65	0.425
Daman	15.2	0.43
Meerut	490	0.46
Agra	653.57	0.49
Allahabad	509.24	0.51
Ludhiana	734.37	0.53
Jamshedpur	387.98	0.59
Visakhapatanam	600	0.62

Notes: MT/d: metric tonnes per day; kg/c/d: kilograms per capita per day.
*The reporting does not seem to be true. It should be in the range of 0.3 (kg/c/d) kilograms per capita per day looking at the size of the city and commercial activities carried out therein.
Source: Akolkar (2005)

The waste generation rates in India are lower than the low-income countries in other parts of the world and much lower compared to developed countries (Annexe Tables A8.1 and A8.2). However, lifestyle changes, especially in the larger cities, are leading to the use of more packaging material and per capita waste generation is increasing by about 1.3 per cent per year. With the urban population growing at 2.7 per cent to 3.5 per cent per annum, the yearly increase in the overall quantity of solid waste in the cities will be more than 5 per cent. The Energy and Resources Institute (TERI) has estimated that waste generation will exceed 260 million tonnes per year by 2047—more than five times the present level.

Cities with 100,000 plus population contribute 72.5 per cent of the waste generated in the country as compared to other 3955 urban centres that produce only 17.5 per cent of the total waste (Table 8.3).

Table 8.3
Waste Generation in Class 1 Cities with Population above 100,000

Type of cities	Tonnes/day	per cent of total garbage
The 7 mega cities	21,100	18.35
The 28 metro cities	19,643	17.08
The 388 class 1 towns	42,635	37.07
Total	83,378	72.50

Note: Mega cities are above 4 million population and metro cities (also known as million plus cities) are the same as the identified cities under the proposed JNNURM (Table A1.1). Class 1 cities with population in the 100,000 to 1 million range are 388 in number.
Source: MOUD (2005)

Physical and chemical characteristics of solid waste in Indian cities vary depending on population size and geographical location (Annexe Tables A8.3, A8.4, A8.7 and A8.8). Though composition of urban waste is changing with increasing use of packaging material and plastics, yet, as compared to developed countries, Indian solid waste still comprises mostly, of large proportions of organic matter as well as inert material (Annexe Tables A8.5 and A8.6).

Reasons for Inadequacy and Inefficiency in Services

Apathy of Municipal Authorities

Though municipal authorities have held the responsibility of managing solid waste from their inception over three centuries ago, the issue seldom got the attention it deserved. Elected representatives as well as the municipal authorities generally relegate the responsibility of managing municipal solid waste (MSW) to junior officials such as sanitary inspectors. Systems and practices continue to be outdated and inefficient. No serious efforts are made to adapt latest methods and technologies of waste management, treatment and disposal. Though a large portion of the municipal budget is allotted for solid waste management, most of it is spent on the wages of sanitation workers whose productivity is very low. There are no clear plans to enhance their efficiency or improve working conditions through the provision of modern equipment and protective gear. Unionization of the workers, politicization of labour unions and the consequent indiscipline among the workforce are all results of bad working conditions and inept handling of labour issues.

Almost all the 3955 towns with population below 100,000 run SWM services rather unprofessionally. They depend on sanitary inspectors to manage solid waste with the help of sanitation workers. In many small towns, even qualified sanitary inspectors are not posted and services are left in the hands of unqualified supervisors.

The situation of cities with 100,000 plus population is somewhat better, though far from satisfactory. In these cities, generally there are health officers who head the SWM department. In some of the larger cities qualified engineers supervise SWM seeking technical inputs from doctors as well.

Absence of Community Participation

Community participation has a direct bearing on efficient SWM. Yet, the municipal authorities have failed to mobilize the community and educate citizens on the rudiments of handling waste and proper practices of storing it in their own bins at the household-, shop- and establishment-level. In the absence of a basic facility of collection of waste from source, citizens are prone to dumping waste on the streets, open spaces, drains, and water bodies in the vicinity creating insanitary conditions. Citizens assume that waste thrown on the streets would be picked up by the municipality through street sweeping.

For the general public, which is quite indifferent towards garbage disposal etiquette, the onus of keeping the city clean is entirely on the ULBs. This mind set is primarily responsible for the unscientific systems of waste management in the country.

Drawbacks in Present SWM Services

No Storage of Waste at Source

There is no practice of storing the waste at source in a scientifically segregated way. Citizens have not been educated to keep domestic, trade, and institutional bins for storage of waste at source and stop littering on the streets.

No System of Primary Collection from the Doorstep

There is no public system of primary collection from the source of waste generation. The waste discharged here and there is later collected by municipal sanitation workers through street sweeping, drain cleaning, etc. Street sweeping has, thus become the principal method of primary collection.

Irregular Street Sweeping

Even street sweeping is not carried out on a day-to-day basis in most cities and towns in India. Generally commercial roads and important streets are prioritized and rest of the streets are swept occasionally or not swept at all. Generally, no sweeping is done on Sundays and public holidays and a back log is created on the next working day.

The tools used for street sweeping are generally inefficient and out-dated. For instance, the broom with a short handle is still in use forcing sweepers to bend for hours resulting in fatigue and loss of productivity. Traditional handcarts/tricycles are used for collection, which do not synchronize with the secondary storage systems. Waste is deposited on the ground necessitating multiple handling.

There are no uniform yardsticks adopted for street sweeping. Though, some states/cities have prescribed work-norms, these are not very scientific. Most of the cities allocate work to sanitation workers on ad hoc basis. The work distribution ranges between 200 metres to 1000 metres of street sweeping each day. Some sanitation workers are found under worked while some over burdened.

Waste Storage Depots

As waste is collected through traditional handcarts/tricycles that can carry only a small quantity of waste at a time, there is a practice to set up depots for temporary storage of waste to facilitate transportation through motorized vehicles. Generally, open sites or round cement concrete bins, masonry bins or concrete structures are used for temporary bulk storage, which necessitates multiple handling of waste. Waste often spills over which is both unsightly as well as unhygienic.

Transportation of Waste

Transportation of waste from the waste storage depots to the disposal site is done through a variety of vehicles such as bullock carts, three-wheelers, tractors, and trucks. A few cities use modern hydraulic vehicles as well. Most of the transport vehicles are old and open. They are usually loaded manually. The fleet is generally inadequate and utilization inoptimal. Inefficient workshop facilities do not do much to support this old and rumbling squad of squalid vehicles. The traditional transportation system does not synchronize with the system of primary collection and secondary waste storage facilities and multiple manual handling of waste results.

Processing of Waste

Generally no processing of municipal solid waste is done in the country. Only a few cities have been practising de-centralized or centralized composting on a limited scale using aerobic or anaerobic systems of composting. In some towns un-segregated waste is put into the pits and allowed to decay for more than six months and the semi-decomposed material is sold out as compost. In some large cities aerobic compost plants of 100 MT to 700 MT capacities are set up but they are functioning much below installed capacity. A few towns are practising vermi-composting on a limited scale.

Disposal of Waste

Disposal of waste is the most neglected area of SWM services and the current practices are grossly unscientific. Almost all municipal authorities deposit solid waste at a dump-yard situated within or outside the city haphazardly and do not bother to spread and cover the waste with inert material. These sites emanate foul smell and become breeding grounds for flies, rodent, and pests. Liquid seeping through the rotting organic waste called leachate pollutes underground water and poses a serious threat to health and environment.

Landfill sites also release landfill gas with 50 to 60 per cent methane by volume. Methane is 21 times more potent than carbon dioxide aggravating problems related to global warming. It is estimated by TERI that in 1997 India released about 7 million tonnes of methane into the atmosphere. This could increase to 39 million tonnes by 2047 if no efforts are made to reduce the emission through composting, recycling, etc.

Technologies Available for Processing, Treatment, and Disposal of Solid Waste

The main technological options available for processing/ treatment and disposal of MSW are composting, vermi-composting, anaerobic digestion/biomethanation, incineration, gasification and pyrolysis, plasma pyrolysis, production of Refuse Derived Fuel (RDF), also known as pelletization and sanitary landfilling/landfill gas recovery. Not all technologies are equally good. Each one of them has advantages and limitations.

Composting

Composting is a technology known in India since times immemorial. Composting is the decomposition of organic

matter by microorganism in warm, moist, aerobic and anaerobic environment. Farmers have been using compost made out of cow dung and other agro-waste. The compost made out of urban heterogeneous waste is found to be of higher nutrient value as compared to the compost made out of cow dung and agro-waste. Composting of MSW is, therefore, the most simple and cost effective technology for treating the organic fraction of MSW. Full-scale commercially viable composting technology is already demonstrated in India and is in use in several cities and towns. Its application to farm land, tea gardens, fruit orchards or its use as soil conditioner in parks, gardens, agricultural lands, etc., is however, limited on account of poor marketing.

Main advantages of composting include improvement in soil texture and augmenting of micronutrient deficiencies. It also increases moisture-holding capacity of the soil and helps in maintaining soil health. Moreover, it is an age-old established concept for recycling nutrients to the soil. It is simple and straightforward to adopt, for source separated MSW. It does not require large capital investment, compared to other waste treatment options. The technology is scale neutral.

Composting is suitable for organic biodegradable fraction of MSW, yard (or garden) waste/waste containing high proportion of lignocelluloses materials, which do not readily degrade under anaerobic conditions, waste from slaughterhouse and dairy waste.

This method, however, is not very suitable for wastes that may be too wet and during heavy rains open compost plants have to be stopped. Land required for open compost plants is relatively large. Also, issues of methane emission, odour, and flies from badly managed open compost plants remain. At the operational level, if waste segregation at source is not properly carried out there is possibility of toxic material entering the stream of MSW. It is essential that compost produced be safe for application. Standardization of compost quality is, therefore, necessary. The MSW (Management and Handling) Rules 2000 (MSW Rules 2000) have specified certain limits to acceptable percentage of heavy metals in compost produced from MSW and a mechanism is put in place to ensure that the same are strictly implemented.

Marketing of compost is a major concern for private operators. Lack of awareness among the farmers regarding the benefits of using compost is an impediment to its sale. Also, there is a need to market the product near the compost site to minimize transportation cost.

Composting projects in India

There are many small and large composting projects in the country though the exact figure is not known. The treatment capacity designed for these facilities in large cities ranges from 100–700 TPD (Annexe Table A8.9). Many have been closed down or are functioning at a lower capacity. Those functioning are generally being managed by the private sector through a contractual arrangement with municipal authorities. Most of the plants are facing a problem of marketing the compost due to an ineffective marketing mechanism.

The capital investment requirement for such projects is typically in the range of Rs 10 to 20 million per 100 MT per day plant depending on sophistication.

Vermi Composting

Vermi-compost is the natural organic manure produced from the excreta of earthworms fed on scientifically semi-decomposed organic waste. A few vermi composting plants generally of small size have been set up in some cities and towns in India, the largest plant being in Bangalore of about 100 MT/day capacity. Normally, vermi-composting is preferred to microbial composting in small towns as it requires less mechanization and it is easy to operate. It is, however, to be ensured that toxic material does not enter the chain which if present could kill the earthworms.

Waste to Energy

Even though the technology of waste to energy (WTE) projects has been proven worldwide, its viability and sustainability is yet to be to be demonstrated and established in the country. The main factors that determine the techno-economic viability of WTE projects are quantum of investment, scale of operation, availability of quality waste, statutory requirements and project risks.

WTE projects generally involve higher capital investment and are more complex when compared to other options of waste disposal, but as pointed by Ministry of Non-Conventional Energy Sources (MNES), gains in terms of waste reduction, energy, etc. are also higher. Such plants are financially viable in developed countries mainly because of the tipping fees/gate fees charged by the facility for the service of waste disposal, in addition to its revenue income from power sales. It is thereafter the sole responsibility of the facility operator to treat and dispose of the accepted waste as per statutory requirements. However, at present in India, revenue from power sales is the only source of revenue for WTE plants.

Most cities generate sufficient waste quantities to enable projects of total power generation capacities ranging from 5–50 MW, which corresponds to MSW generation ranging from 500–5000 TPD. Technologically it is feasible to set up even smaller capacity projects of the 1–5 MW range, corresponding to around 100–500 TPD waste treatment. However, economies of scale generally favour centralized, large-scale projects. Waste

from a number of adjoining regions/cities could be treated at a common WTE facility; however, in such cases the costs of waste transportation versus projects benefits must be carefully evaluated.

Enforcement of strict measures for segregation of waste at source in order to avoid mixing of undesirable waste streams will play a major role in making a WTE facility financially viable. The statutory requirements that a WTE facility must comply with, will directly govern the cost of the stringent environmental pollution control measures to be incorporated in the overall facility.

The terms for MSW supply, allotment of land and sale/purchase of power directly affect the net revenue to the facility operator and are factors in determining the financial viability of projects and private sector participation. Since FI lending for such facilities is usually project based, it is critical that all project risks be suitably addressed, with back-to-back agreements. The energy off take agreements must be in place, to ensure marketability.

Some waste to energy technologies are discussed hereunder.

Anaerobic Digestion and Biomethanation

Biomethanation is a comparatively well-established technology for disinfections, deodorization and stabilization of sewage sludge, farmyard manures, animal slurries, and industrial sludge. Its application to the organic fraction of MSW is more recent and less extensive. It leads to bio-gas/power generation in addition to production of compost (residual sludge). This method provides a value addition to the aerobic (composting) process and also offers certain other clear advantages over composting in terms of energy production/consumption, compost quality and net environmental gains.

This method is suitable for kitchen wastes and, other putrescible wastes, which may be too wet and lacking in structure for aerobic composting. It is a net energy-producing process (100–150 kWh per tonne of waste input). A totally enclosed system enables all the gas produced to be collected for use. A modular construction of plant and closed treatment needs less land area. This plant is free from bad odour, rodent and fly menace, visible pollution, and social resistance. It has potential for co-disposal with other organic waste streams from agro-based industry. The plant can be scaled up depending on the availability of the waste.

However, this method is suitable for only the organic biodegradable fraction of MSW; it does not degrade any complex organics or oils, grease, or ligno-cellulosic materials such as yard waste. Similar to the aerobic composting process input waste needs to be segregated for improving digestion efficiency (biogas yield) and the quality of residual sludge. While the liquid sludge can be used as rich organic manure, either directly or after drying, its quality needs to be ensured to meet statutory standards. No grinding of waste material should take place. Wastewater generated in the plant requires treatment before disposal to meet statutory standards. Biogas leakage poses a small environmental and fire hazard. This plant is more capital intensive than aerobic composting. The biogas technology developed at BARC in India and commercialized as Nisarguna Biogas Plant is an improvement on this technology (Box 8.1).

Biomethanation plants in India

Recently a 5 MW power plant based on biomethanation technology was constructed and operationalized at Lucknow but unfortunately it had to be closed down for various reasons, one among them being non-supply of appropriate quality of MSW to the plant. The organic content in the waste supplied to the plant is reported to have been as low as 15 per cent. Biomethanation technology on a small scale is also functioning at Vijayawada and at other places in the country for the treatment of selected organic waste collected from canteens, vegetable markets, etc.

Production of Refuse Derived Fuel (RDF) or Pelletization

It is basically a processing method for mixed MSW, which can be very effective in preparing an enriched fuel feed for thermal processes like incineration or industrial furnaces.

The RDF pellets can be conveniently stored and transported long distances and can be used as a coal substitute at a lower price. As pelletization involves significant MSW sorting operations, it provides a greater opportunity to remove environmentally harmful materials from the incoming waste prior to combustion.

The process, however, is energy intensive and not suitable for wet MSW during rainy season. If RDF fluff/pellets are contaminated by toxic/hazardous material, the pellets are not safe for burning in the open or for domestic use.

RDF Plants in India: Such plants are in the initial stage of development in India. The viability and sustainability of the technology process and projects underway, are still being examined.

The Department of Science and Technology (DST) of the Technology Information, Forecasting and Assessment Council (TIFAC) New Delhi had initially perfected the technology of processing municipal solid waste to separate the combustible fraction and carry out densification into fuel pellets to a scale of 2 tonnes per hour in a demonstration plant at the Deonar Dump Yard of the Mumbai Municipal Corporation. Fuel pellets produced in the demo plant were found to have a

Box 8.1
Nisarguna Biogas Plant

The plant can use vegetable and fruit market waste, fruit and food processing industries waste, domestic and institutional kitchen waste, paper, garden waste, animal and abattoir waste etc. However, the waste that cannot be treated and to be strictly avoided are coconut shells, egg shells, big bones, plastic/polythene, glass, metal, sand, silt, debris and building materials, wood, cloth/clothes, ropes, nylon threads, batteries, tyres/rubber, hazardous and chemical industries waste etc. Municipal authorities, therefore, have to ensure segregated waste before setting up the biogas plant.

Major components of the plants are a mixture/pulper (5 HP motor) for crushing the solid waste, pre-mix tank(s), predigester tank, air compressor, slow water heater, main digestion tank, gas delivery system, manure pits, tank for recycling for water and water pump and gas utilization system. The waste is homogenized in a mixer using water. This slurry enters the predigesting tank where aerobic thermophilic bacteria proliferate and convert part of this waste into organic acids. The slurry then enters the main tank where it undergoes mainly anaerobic degradation by a consortium of archaebacteria belonging to the Methanococcus group. These bacteria are naturally present in the alimentary canal of ruminant animals (cattle). They produce mainly methane from the cellulosic materials in the slurry. The undigested lignocellulosic and hemi-cellulosic materials then are passed on in the settling tank. After about a month, high quality manure can be dug out from the settling tanks. There is no odour to the manure at all. The organic contents are high and this can improve the quality of humus in soil, which in turn is responsible for the fertility.

As the gas is generated in the main tank, the dome is slowly lifted up. This gas is a mixture of methane (70–5 per cent), carbon dioxide (10–15 per cent) and water vapours (5–10 per cent). It is taken through GI pipeline to the lampposts. Drains for condensed water vapour are provided on line. This gas burns with a blue flame and can be used for cooking.

The gas generated in this plant is used for gas lights fitted around the plant. The potential use of this gas would be for cooking purposes. It can also be used to produce electricity in a dual fuel biogas–diesel engine. The manure generated is high quality and can be used for gardening and agricultural purposes. The plant can be installed at hotel premises, army/big establishment canteens (private/ government), residential schools/colleges, housing colonies, religious places/temple trusts, hospitals, hotels, sewage treatment plants etc. There are 5 such plants already in operation and about 5 others are proposed mostly in Maharashtra. The plant should be closer to source of waste being produced and the point of utilization of biogas power. The site should be free from underground cables, drainage pipes etc. and water table should be below 3 metres.

It is estimated that the life of the plant could be 20–30 years and payback period is estimated to be 4–5 years (Table B8.1.1).

Table B8.1.1
Cost Details, Savings and Other Requirements in Respect of Various Capacities of Nisarguna Biogas Plant

Treatment capacity (tonnes/day)	Installation cost (Rs in lakhs)	Monthly operation and maintenance charges (Rs)	Methane generation (Cu m)	Manure production (tonnes/day)
1	5–6	8000	100–120	0.1
2	9–10	12,000	200–240	0.2
4	20–22	15,000	400–480	0.3
5	28–30	22,000	500–600	0.5
10	65–70	50,000	1000–1200	2.5

Note: This is an approximate cost for biogas generation plant and may increase by 10–20 per cent depending on location, site specific parameters, cost of materials, labour cost etc. in different states/ cities. Cost of additional infrastructure like office space, toilets, security, compound wall, flood control measures etc. and for power generation will be extra, if required.

calorific value consistently in excess of 3000 k cal per kg and the fuel was test marketed around Rs 1000 per tonne in and around Mumbai. Thereafter, the DST technology of processing MSW into fuel pellets was transferred to M/s. Selco International Limited, Hyderabad for scaling up and commercial operation. The Technology Development Board of DST and TIFAC has assisted Selco to set up a 6.6 MW power plant using MSW derived fuel and generate electricity. Selco is using 400 tonnes of MSW to convert into fluff and mix it with 30 per cent rice husk for generation of power. DST has also transferred the technology to M/s Sriram Energy Systems Ltd to set up a similar plant at Vijayawada. Both these plants are operational since November 2003. The proportion of use of agro waste along with municipal solid waste claimed by the operators of these facilities is being challenged by some people and the matter is under judicial scrutiny.

Incineration

This method, commonly used in developed countries is most suitable for high calorific value waste with a large component of paper, plastic, packaging material, pathological wastes, etc. It can reduce waste volumes by over 90 per cent and convert waste to innocuous material, with energy recovery. The method is relatively hygienic, noiseless, and odourless, and land requirements are minimal. The plant can be located within city limits, reducing the cost of waste transportation.

This method, however, is least suitable for disposal of chlorinated waste and aqueous/high moisture content/low calorific value waste as supplementary fuel may be needed to sustain combustion, adversely affecting net energy recovery. The plant requires large capital and entails substantial operation and maintenance costs. Skilled personnel are required for plant operation and maintenance. Emission of particulates, SO_x, NO_x, chlorinated compounds in air and toxic metals in particulates concentrated in the ash have raised concerns.

Incinerators in India

An incinerator capable of generating 3.75 MW power from 300 TPD MSW was installed at Timarpur, Delhi in the year 1987. It could not operate successfully due to low net calorific value of MSW. The plant is lying idle and the investment is wasted.

Pyrolysis/Gasification, Plasma Pyrolysis Vitrification (PPV)/Plasma Arc Process

Pyrolysis gasification processes are established for homogenous organic matter like wood, pulp, etc., while plasma pyrolysis vitrification is a relatively new technology for disposal of particularly hazardous wastes, radioactive wastes, etc. Toxic materials get encapsulated in vitreous mass, which is relatively much safer to handle than incinerator/gasifier ash. These are now being offered as an attractive option for disposal of MSW also. In all these processes, besides net energy recovery, proper destruction of the waste is also ensured. These processes, therefore, have an edge over incineration.

This process produces fuel gas/fuel oil, which replace fossil fuels and compared to incineration, atmospheric pollution can be controlled at the plant level. NO and SO gas emissions do not occur in normal operations due to the lack of oxygen in the system.

It is a capital and energy intensive process and net energy recovery may suffer in case of wastes with excessive moisture and inert content. High viscosity of Pyrolysis oil maybe problematic for its transportation and burning. Concentration of toxic/hazardous matter in gasifier ash needs care in handling and disposal.

No commercial plant has come up in India or else where for the disposal of MSW. It is an emerging technology for MSW, yet to be successfully demonstrated for large-scale application.

Sanitary Landfills and Landfill Gas Recovery

Sanitary landfills are the ultimate means of disposal of all types of residual, residential, commercial and institutional waste as well as unutilized municipal solid waste from waste processing facilities and other types of inorganic waste and inerts that cannot be reused or recycled in the foreseeable future.

Its main advantage is that it is the least cost option for waste disposal and has the potential for the recovery of landfill gas as a source of energy, with net environmental gains if organic wastes are landfilled. The gas after necessary cleaning, can be utilized for power generation or as domestic fuel for direct thermal applications[1]. Highly skilled personnel are not required to operate a sanitary landfill.

Major limitation of this method is the costly transportation of MSW to far away landfill sites. Down gradient surface water can be polluted by surface run-off in the absence of proper drainage systems and groundwater aquifers may get contaminated by polluted leacheate in the absence of a proper leacheate collection and treatment system. An inefficient gas recovery process emits two major green house gases, carbon dioxide and methane, into the atmosphere. It requires large land area. At times the cost of pre-treatment to upgrade the gas quality and leacheate treatment may be significant. There is a risk of spontaneous ignition/explosion due to possible build up of methane concentrations in air within the landfill or surrounding enclosures if proper gas ventilation is not constructed.

Urban Local bodies generally find it very difficult to locate a suitable landfill site, which meets the requirements of MSW Rules due to public resistance as invariably, no one wants landfills close to their property. This is popularly known as the Not In My Backyard (NIMBY) Syndrome. The cost of construction and operation and maintenance of an engineered landfill is also high as compared to the minimal expenditure incurred today in the crude dumping of waste. Smaller landfills with overhead costs turn out to be much more expensive as compared to regional landfills run on a cost-sharing basis. The Maharashtra SWM Cell has estimated that a small landfill, may cost over Rs 1000 per MT of waste as compared to Rs 200 per MT of waste disposed at a commonly shared facility.

In India disposal of organic waste at the landfill is prohibited and it is made mandatory to treat the organic

[1] In India, organic waste is not to be put in landfills, hence there does not exist the potential for this.

fraction of municipal solid waste before disposal of waste. The scope of landfill gas recovery is, therefore, minimized in the Indian situation.

Sanitary landfill sites in India

Until recently there was not a single sanitary landfill site in India. All cities and towns without exception dispose waste most unscientifically in low lying areas or the lands designated for the purpose within or outside the city. In most of the cities the waste is not even spread or covered to prevent unsightly appearance of foul smell. No pollution prevention measures are taken. Of late four sites have been constructed at Surat (Gujarat), Pune (Maharashtra), Puttur and Karwar (Karnataka). A few more sites are under construction. Under the Municipal Solid (Management and Handling) Rules 2000, it is imperative for all local bodies in the country to have sanitary landfill sites that meet the requirements of law. As construction of sanitary landfills is quite expensive and needs professional management, siting of regional facilities is, therefore, being actively considered in India in some states of West Bengal, Gujarat, Rajasthan, etc.

Factors Governing Choice of Technology

The decision to implement any particular technology needs to be based on its techno-economic viability, sustainability, as well as environmental implications, keeping in view the local conditions and the available physical and financial resources. The key factors are:

- the origin and quality of the waste;
- presence of hazardous or toxic waste;
- availability of outlets for the energy produced;
- market for the compost/anaerobic digestion sludge;
- energy prices/buyback tariff for energy purchase;
- cost of alternatives, land price and capital and labour cost;
- capabilities and experience of the technology provider.

It needs to be ensured that any proposed facility fully complies with the environmental regulations as laid down in the Municipal Solid Waste (Management and Handling) Rules 2000 issued by the Ministry of Environment and Forests and as may be amended from time to time.

Moreover, it has been scientifically established that extensive use of chemical fertilizers, has resulted in fertility loss and decrease in carbon content of the soil. Hence, there is an urgent need to provide humus to the soil to enable it to regain its fertility as well as water retaining capacity. Studies by the Indian Council for Agricultural Research have shown that compost used with chemical fertilizers has shown 15 per cent increase in food production creating a strong case for its promotion.

Experience shows that the WTE have been successful in developing countries to handle large quantities of MSW. Two RDF based waste to energy projects have recently been commissioned in India and few more are under various stages of development. Their results are encouraging; but yet to be confirmed through independent verification as their success is being contested.

Judicial Intervention to Improve the System

A public interest litigation was filed by Almitra H. Patel and another in The Supreme Court of India in the year 1996 (Special Civil Application No. 888 of 1996) against the Government of India, all state governments and several municipal authorities in the country alleging that they have failed to discharge their obligatory duty to manage municipal solid waste appropriately. The Supreme Court set up an Expert Committee, which deliberated on the issue after consulting 300 municipal authorities in class I cities and other stakeholders by holding regional workshops in Mumbai, Delhi, Chennai, and Kolkata. It submitted its report to the Supreme Court in March, 1999 making detailed recommendations, which were circulated to all the class I cities and various stakeholders through the Government of India with interim directions for implementation.

To ensure compliance, the principal recommendations of the Supreme Court appointed Committee have been incorporated in the Municipal Solid Waste (Management and Handling) Rules 2000 notified by the Ministry of Environment and Forest in September 2000.

Municipal Solid Waste (Management and Handling) Rules 2000

The Ministry of Environment and Forest notified Municipal Solid Waste (Management and Handling) Rules 2000 after widely circulating the draft rules in 1999 inviting objections and suggestions if any and made it mandatory for all municipal authorities in the country, irrespective of their size and population, to implement the rules. To improve the systems the following seven directives are given.

1. Prohibit littering on the streets by ensuring storage of waste at source in two bins; one for biodegradable waste and another for recyclable material.
2. Primary collection of biodegradable and non-biodegradable waste from the doorstep, (including slums and squatter areas) at pre-informed timings on a day-to-day basis using containerized tricycle/handcarts/pick up vans.
3. Street sweeping covering all the residential and commercial areas on all the days of the year irrespective of Sundays and public holidays.

4. Abolition of open waste storage depots and provision of covered containers or closed body waste storage depots.
5. Transportation of waste in covered vehicles on a day to day basis.
6. Treatment of biodegradable waste using composting or waste to energy technologies meeting the standards laid down.
7. Minimize the waste going to the land fill and dispose of only rejects from the treatment plants and inert material at the landfills as per the standards laid down in the rules.

The rules are to be implemented and monitored in a time bound manner (Table 8.4).

Table 8.4
Timeframe for the Implementation of the Rules

S.no.	Compliance criteria	Schedule
A	Setting up of waste processing and disposal facilities	By 31 December 2003 or earlier
B	Monitoring the performance of waste processing and disposal facilities	Once in six months
C	Improvement of existing landfill sites as per provisions of these rules	By 31 December 2001 or earlier
D	Identification of landfill sites for future use and making site(s) ready for operation.	By 31 December 2002 or earlier

Responsibility for Implementation

The entire responsibility of implementation as well as development of required infrastructure lies with municipal authorities. They are directed to obtain authorization from the state pollution control boards/committees for setting up waste processing and disposal facilities and furnish annual report of compliance. The Secretary, Urban Development Department of the respective state government is responsible for the enforcement of the provisions in metropolitan cities. A District Magistrate or a Deputy Commissioner of the concerned district is responsible for the enforcement of these provisions within the territorial limit of his jurisdiction. The state pollution control boards are expected to monitor the compliance of standards regarding ground water, ambient air, leacheate quality and the compost quality including incineration standards as specified in the rules. The state board or the committee is directed to issue authorization to the municipalities when asked for within 45 days and the central pollution control board is expected to coordinate with the state boards in regard to implementation of the rules. Several training programmes and workshops have been organized by the central government, state governments, Central Pollution Control Board, State Pollution Control Boards as well as national and international institutions to guide the cities and towns in implementing the rules expeditiously.

Manual for Municipal Authorities

Government of India, Ministry of Urban Development set up an expert panel to prepare a national manual on solid waste management to help the municipal authorities adopt appropriate systems of solid waste management. The manual was published in May 2000 and made available to all the states.

Compliance of MSW Rules 2000

Complete compliance within 31 December 2003 remains a distant dream. Many cities and towns have not even initiated measures whereas some cities have moved forward on their own or under the pressure of Supreme Court, respective state governments, pollution control boards, etc. There is no consolidated official data available about the status of compliance of MSW Rules in the country though all the states are expected to submit their annual reports. A study was conducted to ascertain the status of compliance of MSW Rules 2000 by class I cities of India. One hundred twenty-eight class I cities of India responded and the status of compliance as on 1 April 2004 shows that there is insignificant progress in the matter of processing of waste and construction of sanitary landfills, and only about one-third compliance has taken place in the remaining five steps (Figure 8.1).

Reasons for Non-Compliance

As per municipalities compliance in waste collection is constrained by:

- lack of public awareness, motivation, education;
- lack of wide publicity through electronic and print media;
- lack of finances to create awareness;
- resistance to change;
- difficulty educating slum dwellers;
- lack of sufficient knowledge on benefits of segregation;
- non cooperation from households, trade and commerce;
- unwillingness on part of citizens to spend on separate bin for recyclables;
- lack of litter bins in the city;
- non availability of primary collection vehicles and equipment;
- lack of powers to levy spot fines;
- lack of financial resources for procurement of tools and modern vehicles.

In creating treatment and disposal facilities, the constraints outlined were:

- paucity of financial resources as well as lack of support from state government;

- non-availability of appropriate land;
- prohibitive time and cost considerations in land acquisition and implementation of treatment and landfill technologies;
- lack of technical know how and skilled manpower for treatment and disposal of waste;
- low quality of municipal solid waste;
- delay in clearance of disposal sites.

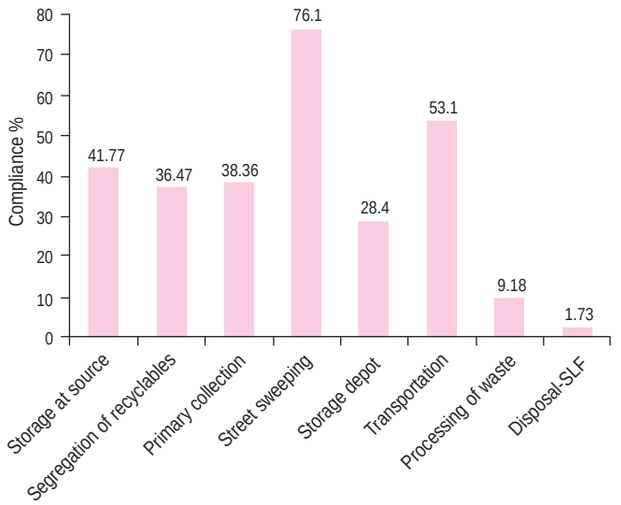

Fig. 8.1 Status of Compliance of MSW Rule 2000 by Class I cities as on 1 April 2004

Source: Asnani (2004)

However, there is a definite awareness among local bodies as well as policymakers to solid waste management systems. There has at least been some progress in the right direction in five years' time, which is not a mean achievement for India. Even the US, which has been trying to follow efficient SWM practices for the last 25 years, only 25 per cent solid waste is recycled and 15 per cent waste is utilized for waste to energy and remaining 50 per cent of waste including organic matter is being land-filled even today. The situation in India is fast improving with regular monitoring by the Supreme Court, initiatives by various state governments, large financial support from the central government on the recommendation of 12th Finance Commission, allocation of urban renewal funds to the states and technical and financial support from various ministries and national and international organizations.

Strategy to Implement MSW Rules 2000

Five years have passed since the notification of MSW Rules, 2000 and the time limit for the implementation of the rules has run out in December 2003. Yet, there are cities, which have not initiated any measures at all. There are several which are still grappling with choice of technology and other operational issues. Authorities need to take the implementing of the rules seriously and find 'out of the box' solutions. Days are not far when city governments may be hauled up by the courts and state pollution control boards (SPCBs) for non-compliance.

Given the lack of in-house capability of municipal authorities and paucity of financial resources, it is desirable to outsource certain services and resort to private sector/NGO participation in providing SWM services.

Private Sector Participation in SWM at Urban Local Body Level

Experience the world over has shown that private sector participation (PSP) results in cost savings and improvement in efficiency and effectiveness in service delivery mainly due to financial and managerial autonomy and accountability in private sector operations. Besides, it brings in new investment and better technologies. In developed countries the private sector manages most of the SWM services.

In India, by and large, municipal authorities are providing solid waste management services departmentally. Resistance from labour unions and interpretations of labour laws have discouraged city administrations from contracting out services to private operators. Of late, some experiments to privatize certain SWM services have demonstrated improvement in the level of services in a cost-effective manner.

The Supreme Court of India has cleared the doubts on legal implications under the Contract Labour (Regulation and Abolition) Act 1970 by its decision in Special C.A. No. 6009–6010 of 2001 in Steel Authority of India Limited and others versus National Union Water Front Workers and others in August 2001. This has paved the way for municipal authorities to contract out certain SWM services. Private sector participation has been attempted in door-to-door collection of waste, street sweeping, secondary storage of waste, transportation of waste, composting of waste or power generation from waste and final disposal of waste at the engineered landfill.

The present capacity of municipalities in India to manage the privatization process is, however, extremely limited. There is a need for developing in-house financial and managerial capability to award contracts to private sector and monitoring the services provided since the onus of ensuring proper service delivery and compliance of standards, remains with the local body.

Service contracts

Contracts are generally given for door-to-door collection of waste in the morning hours with or without the equipment

of the contractor. This activity is labour intensive and generally taken up by small contractors or NGOs at a low cost. Cities of Bangalore, Ahmedabad, Nagpur, Jaipur, North Dumdum, New Barrackpore (West Bengal), Gandhinagar, Vejalpur (Gujarat) are some examples.

Different models are adopted in different cities. At some places, contracts are given to private operators for doorstep collection and transportation based on wards allotted to each contractor, who appoints his own manpower, uses his own tools, vehicles and equipment and is paid per month by the municipal corporation for the services rendered (for example, Bangalore, Jaipur, and Nagpur). In other cases, contracts are awarded to NGOs for door-to-door collection and supervision only against a monthly payment (for example, Vejalpur). In some towns contracts are given to NGOs or individuals to collect the waste from door-to-door but the contractor is expected to recover the user fee from the citizens directly as prescribed by the local body (examples would be Gandhinagar, North Dumdum, New Barrackpore, etc.). In Ahmedabad door-to-door collection is entrusted to residents welfare associations and associations of backward classes and they are given a monthly grant for supporting sanitation workers and annual grants for purchase of tools, etc. On an average 200 houses are served by one part time sanitation worker in a four hour shift. Contract packages are made by municipal authorities keeping in mind the work to be done and the minimum wages payable under the law. The contractor is paid per month on the basis of the number of houses served.

Street sweeping

Street sweeping contracts are less common. They are generally given to cover un-served and newly developed areas. Payments are made per km area served or on the basis of unit area fixed for street sweeping. Surat was perhaps the first city to award contracts for brushing the streets at night after the plague in 1994 and transformed the city into one of the cleanest in India. Following this example, Hyderabad has successfully outsourced the sweeping of 75 per cent of its streets using 161 small contracts, applying a unique unit area method of 8 km road length per 18 sanitation workers.

Secondary storage and transportation

Municipal authorities enter into secondary storage and/or transportation contracts to avoid investing in vehicles and equipment and to avail of a more efficient system. In such an arrangement, the private firms provide containers and/or vehicles with drivers as well as fuel. The onus of maintaining the fleet of vehicles also lies with them. Such contractors are either paid per trip to the treatment/disposal site or per tonne of waste transported (examples can be found in Ahmedabad, Surat, and Mumbai)

BOOT, BOO, and DBO Contracts for Treatment and Disposal of Waste

Generally, municipal authorities in our towns and cities are not equipped to handle treatment and disposal of waste, which are highly technical operations. Private sector participation is thus preferred and is gradually picking up in the country. Build, Own, Operate and Transfer (BOOT) and Build, Own and Operate (BOT) are the most popular models of concession agreements in vogue in the country. Cities such as Kolkata, Hyderabad, Vijayawada, Ahmedabad, Trivandrum, and Thane are examples of such contracts for the construction of compost plants or waste to energy plants. In most such cases the municipal authority provides land on a token lease rent and free garbage at the plant site. The private firm invests money to build, own and operate the facility for a term of normally 20 to 30 years sufficient for a reasonable return on investment. At the end of the BOOT contract period the facility is to be transferred to the local body.

In case of BOO, the plant is dismantled and site is cleared in line with the concession agreement between the service provider and the municipality. The private firm earns from marketing of compost or power and recyclable material recovered during the process. Local bodies prefer BOOT model as they do not have to invest any money and a facility created by private firm is eventually transferred to them. In such contracts ULBs do demand some payment in the form of royalty from the private sector, which is of the order of Rs 10 per MT of raw waste or Rs 20 to Rs 35 per MT of compost produced. The private entrepreneurs are, however, requesting royalty waiver as the cost of composting has gone up with the MSW Rules 2000.

Cities such as Mysore, Calicut, Kochi, Shillong, and Puri have adopted the design, build and operate (DBO) model for setting up compost plants. Under this arrangement, funds, land, and garbage are provided by the municipal authorities whereas the private firm is responsible for designing, building, and operating the facility. The ownership of the plant remains with the ULB. The private firm is given time-bound contracts on mutually agreed terms and conditions.

Privatization of Disposal of Waste

In case of disposal of waste, there are no examples of private sector participation in India as no such plants existed thus far. However, the concept of paying tipping fees is gaining acceptance with a beginning made by the Municipal Corporation of Bangalore. The BMP (Bangalore Mahanagar Palike) is using an integrated treatment and disposal facility

for the treatment and disposal of 1000 tonnes of waste per day. Here, the contractor is paid a tipping fee of Rs 195/tonne only for the disposal of rejects not exceeding 30 per cent of the total quantity of waste delivered.

Based upon technology and investment requirements, various profiles of contracting with private firms are emerging. Mega cities namely Delhi, Mumbai, Bangalore, Kolkata, Chennai, Hyderabad, and Ahmedabad have gone in for large contracts and have attracted national and international firms. In some cases cities have strategically gone in for small waste collection and transportation contracts promoting local firms with modest financial resources. Cities must ensure that such service responsibility is distributed amongst multiple firms or between private firms and ULB staff so that in case one firm fails others can take over without disrupting the service.

Role of Resident Welfare Associations (RWAs), Non-governmental Organizations (NGOs), and Community Based Organizations (CBO)

There is enormous potential to involve RWAs, NGOs and CBOs in SWM services in a cost-effective manner without getting into contracts with private operators. With some support from the ULB in the form of grant or subsidy, the community is keen to manage its own waste. There are NGOs/CBOs which also promote the welfare of rag pickers. They are willing to come forward to involve the rag pickers in door-to-door collection and source segregation of waste. In this model, followed in Ahmedabad and Ludhiana, there is no contractual relationship between the ULBs and RWAs/NGOs as they only get grants to support their activity carried out through their own labour and grants can be discontinued if purpose is not served.

Obstacles to Private Contracting in SWM

1. *Absence of user charges:* Provision of doorstep waste collection service under MSW Rules 2000 adds to the cost of SWM service and thus affects the finances of ULBs unless they introduce recovery of user fees from the beneficiaries. This is lacking in most of the cities and the contractor is paid out of the general revenue of the local body. This requires the local body to have a sound revenue base from which to allocate resources for SWM. The privatization effort currently underway in North Dumdum and New Barrackpore in West Bengal and Gandhinagar in Gujarat are good examples of user charges levied to sustain door-to-door collection on a long term basis without additional burden on the ULBs.
2. *Absence of a labour rationalization policy:* In some cities as much as 20 to 50 per cent of the ULB staff is engaged in waste collection and transportation. Quite often the staff is more than adequate but underutilized. Private contracting to improve the same service renders the existing staff redundant. It therefore becomes imperative that an adequate staffing plan be drawn up in consultation with the unions to arrive at a judicious combination of labour retrenching; and redeployment.

Initiatives Taken by State Governments to Handle Solid Waste

A few state governments have taken important initiatives towards long-term solutions to SWM catalysed by the MSW Rules 2000.

Karnataka

Karnataka formulated the state policy for implementation of Integrated Solid Waste Management (ISWM) based on MSW Rules 2000 laying down guidelines for all the activities under MSWM, defining roles and responsibilities of all the stake-holders namely, ULBs, elected representatives, waste generators, NGOs, CBOs, SHGs, etc. It created the post of Environmental Engineers in 123 local bodies to build technical capability. SWM Action Plan and Management Plans for 56 cities were prepared based on data pertaining to concerned ULBs. The state also prepared technical manuals on (a) design and specifications of the tools and equipment for SWM and (b) treatment and landfill operations.

To promote SWM practices at the local level it prepared a short film and issued six short books on MSWM for educating stakeholders. A series of workshops was conducted for the local body officials, elected representatives, NGOs, etc., for preparation of action plan, adoption of state policy, identification of best practices, carrying out of Information, Education and Communication (IEC) activities and identifying suitable landfill sites for treatment and disposal of waste.

The state has issued orders for transfer of government land free of cost to the 226 local bodies for sanitary landfills, issued guidelines for identification and purchase of private land for this purpose and, if required, provides 100 per cent financial assistance to purchase the identified land from a budget allocation of Rs 16.1 crore. The government initiated action to develop scientific landfill sites in eight class 1 cities on BOT basis.

Gujarat

Government of Gujarat has set up a state level committee headed by the Principal Secretary, Urban Development and Urban Housing Department and a sub-committee headed by

a subject expert to identify systems for solid waste management. All cities and towns have been advised to implement the recommended systems. Regional and state level workshops have been conducted to provide training to all responsible officers of ULBs and action plans have been prepared for almost all the cities through the Gujarat Municipal Finance Board, a nodal agency of the state government and City Manager's Association, Gujarat. The state government has given Rs 22 crore since 2000 to ULBs of class I cities/towns for the procurement of tools and equipment.

Government of Gujarat has passed a resolution to allot land to municipal corporations at 25 per cent of the market value and to smaller local bodies on a token lease rent for a period of 30 years for treatment and disposal of waste. Thus, 147 out of 149 cities and towns have been able to earmark appropriate land and these sites have been duly authorized by the state pollution control board for treatment and disposal of waste.

The year 2005 has been declared the Year for Urban Development. Under this initiative, construction of treatment and disposal sites in all the 141 municipalities, has been taken up centrally using expert agencies, state government funds and central government grants. For this purpose, the state government has formed a core committee of administrative and technical experts and identified the Gujarat Urban Development Company as a nodal agency to facilitate the construction of treatment and disposal sites through qualified contractors. The work is proposed to be taken up simultaneously in four regions of the Gujarat state.

Besides bearing the full cost of construction of treatment and disposal facilities, using 12th Finance Commission grant and Urban Renewal Mission fund the state government now proposes to give financial support ranging between 50 and 90 per cent to municipalities for tools and equipment for collection, secondary storage, and waste transportation facilities. The entire venture is expected to cost the government of Gujarat Rs 346 crore.

The 141 urban local bodies in the state (other than the corporations) have been grouped in four to six categories and cost estimates have been prepared for the construction of landfill sites and compost plants of standard designs for different levels of cities/towns (Tables 8.5 and 8.6).

The state government is also considering the construction of 44 common waste disposal facilities in lieu of individual landfills to ensure their professional management.

Table 8.5
Cost Estimates for Standard Landfill Sites in Gujarat

Population	No. of landfills	Capacity (CMT)	Optimal population covered	Design Capacity (MT/day)	Cost of cell (5 yrs)	Cost of office, weighbridge etc.	Cost of handling tractors, JCB etc.	Total cost (in Rs lakh)	Total cost per category
120,000 to 193,000	10	38,500	200,000	15	48.00	12.00	18.50	78.50	785.00
75,000 to 120,000	16	30,800	150,000	12	41.00	12.00	5.00	59.40	950.40
60,000 to 75,000	12	20,900	100,000	8	31.40	12.00	6.00	49.40	592.80
15,000 to 60,000	103	15,400	75,000	6	28.00	3.00	6.00	35.00	3605.00
Grand Total	141								5933.20

Note: The cost of approach road will be Rs 600 per sq m, which will have to be added to this cost depending on the road length required.
Source: Asnani (2005)

Table 8.6
Estimates for Standard Compost Plants in Gujarat

S.no.	Population range	No. of cities/towns	No. of compost plants to be constructed	Capacity (in MT)	Optimal population expected to be covered	Landfill design (MT/day)	Cell capacity (CMT) to last for 5yrs	Add 10 per cent for inert material
1	120,000 to 193,000	10	10	40.0	200,000	15	35,000	38,500
2	75,000 to 120,000	16	16	30.0	150,000	12	28,000	30,800
3	60,000 to 75,000	18	18	20.0	100,000	8	19,000	20,900
4	40,000 to 60,000	19	19	15.0	75,000	6	14,000	15,400
5	25,000 to 40,000	43	43	10.0	50,000	4	9500	10,450
6	15,000 to 25,000	35	35	7.5	37,500	3	7000	7700
	Total		141					

Source: Asnani (2005)

West Bengal

The Government of West Bengal has launched a 'West Bengal Solid Waste Management Mission' registered under the West Bengal Societies Registration Act 1961 on 18 May 2005. The mission has been set up under the chairmanship of the Chief Secretary to Government and a technical committee headed by the Secretary, Department of Environment. Regulations have been framed and the powers, duties and functions of the mission as well as technical advisory committee have been laid down. The objective of the mission is to promote modernization of collection and transportation of MSW and facilitate development of cost-effective technology for treatment and disposal of the same in the state. Provision of technical and financial support to municipal bodies, PRIs, and authorities of the statutory area for setting up of regional or common solid waste management facilities is proposed.

The technical committee has prepared an action plan for implementing MSW Rules 2000 in the state. It has been envisaged that 25 to 30 regional facilities would be constructed in the state to cover 126 ULBs including six corporations. One regional facility would serve about five ULBs and each city would share the O&M cost in proportion to the waste delivered for treatment and disposal.

The state government's technical committee has prepared a tentative estimate of over Rs 395 crore for supporting municipal authorities in the state if they agree to enter into a cost sharing arrangement of a little over Rs 15 crore (cost estimates in Table 8.7). Upgrading SWM services would include provisions for public awareness, capacity building of the municipal authorities, procurement of tools, equipment, and vehicles for primary collection, secondary storage and transportation of waste, construction of transfer stations, procurement of large hauling vehicles for transportation, construction of regional as well as individual compost plants and construction of about 25 regional landfill facilities covering the entire state.

The state government proposes to use the funds allocated by the 12th Finance Commission as well as from the urban renewal fund for this purpose. The government of India has allocated Rs 393 crore to the municipalities in the state out of which 50 per cent is earmarked for solid waste management in urban areas. Besides another Rs 1271 crore have been allotted to panchayats out of which the state expects to spend at least 10 per cent on solid waste management making a total Rs 323.60 crore. Some additional funds would be found from the urban renewal grant to be allocated by the government of India and internal resources of the state as well as local bodies.

Rajasthan

The Rajasthan government has issued a policy document for solid waste management after a cabinet approval in the year 2001. This policy document outlines the manner in which private entrepreneurs would be selected for setting up waste to energy or waste to compost plants in the state, the type of facility that would be extended to them and the responsibilities that would be placed with them. The state government has set up a state level empowered committee under the chairmanship of Secretary, Local Self Government to recommend the proposals received for useful conversion of solid waste.

Out of 183 urban local bodies, 152 local bodies have either been allotted land or land has been identified for them for construction of landfill sites. All district collectors have been requested to make land available for landfill sites to the ULBs. Development of landfill sites is in progress under most ULBs

Table 8.7
Cost Estimates for Improving Solid Waste Management Services in West Bengal

Item	Quantity	Cost (Rs crore)	Cost sharing by ULBs (Rs crore)	Cost to be borne by state government (Rs crore)
Public awareness	–	1.50	–	1.50
Capacity building	–	1.50	–	1.50
Containerized tricycles	25,000	20.00	5.0	15.00
Secondary storage containers	4000	10.00	2.0	8.00
Transport vehicles	500	33.75	8.45	25.30
Construction of transfer stations	180	21.60	–	21.60
Large containers for transfer stations	500	7.50	–	7.50
Large hauling vehicles	250	50.00	–	50.00
Construction of compost plants	46	125.00	–	125.00
Engineered landfills	25	125.00	–	125.00
Total		395.85	15.45	380.40

Source: Asnani (2005)

providing approach road, fencing, etc. The landfill sites in six divisional headquarter cities are being developed centrally by Rajasthan Urban Infrastructure Development Project (RUIDP).

Guidelines have been issued to all ULBs for door-to-door collection of garbage and the scheme has already been launched in cities of Jaipur, Ajmer, Jodhpur, Kota, Bhilwara, Pali, Beawar, Jaisalmer, Bharatpur, Alwar, and Ramkanj Mandi. RUIDP is providing equipment for solid waste management to six divisional cities viz., Jaipur, Jodhpur, Ajmer, Kota, Bikaner, and Udaipur. The chief minister has announced assistance of Rs 10 crore to smaller local bodies during the financial year 2005–6 for purchasing tool, equipment and vehicles to improve sanitation facilities in the state.

Maharashtra

All India Institute of Local Self-Government (AIILSG), Mumbai, which is a premier training institution in the country in the field of Municipal administration, organized a state level consultation on SWM in February 2001 for Maharashtra. The consultation succeeded in extracting a commitment from the political and administrative leadership of Maharashtra towards improved solid waste management practices within the framework of the MSW Rules 2000. The path breaking state level consultation was followed by a series of meetings to evolve a consensus for a 'nucleus cell' in the AIILSG to enhance institutional capacity of the ULBs towards understanding the provisions of the MSW rules and selection of technologies for waste management. Accordingly, the SWM Cell was established in the AIILSG and became operational in May 2002.

The cell has organized many training workshops as well as study tours for city managers to visit the United States to learn the latest waste processing technologies. The SWM Cell has been providing useful inputs both to the state government of Maharashtra and the Government of India on the policy issues. Based on the feedback of the field agencies, particularly the ULBs, the cell has referred several issues to the state government for policy decisions and recommended amendments in the statutes governing the ULBs. The cell released status reports of all the cities along with a consolidated action plan in February 2005. It has done a study on the marketability of MSW-derived manure. The study covered all regions and all major crops of the state to estimate the market potential in terms of the quantity and the price of the municipal solid waste derived manure. The cell is also active in preparing and distributing material on the compliance criteria of the MSW Rules and sustainable waste management.

Grant of government land for treatment and disposal

The state government has taken decision to grant government land free of occupancy price to the ULBs for developing sanitary landfills as per the MSW Rules. As a result of this policy decision, with the exception of about 7–8 cities all the councils have acquired land for landfill construction. Two hundred and two sites are good enough for about 25 years. The government has also set up district level committees under District Collectors to coordinate the implementation of the MSW Rules. The implementation of the Rules in the state is particularly lacking in doorstep collection of waste and waste processing (Table 8.8).

Table 8.8
Status of the Implementation of the Rules in Maharashtra

	Compliance by no. of cities/towns out of 247 cities/ towns in the state
Notification on prohibition of littering and storage at source	214
Doorstep collection of waste	95
Identifying land and agency for waste processing	65
Identifying land for landfill for 25 years	202
MPCB authorization for sanitary landfill granted	242

The government is also considering a capital grant to the cities for developing the infrastructure required for processing and disposal facility. The SWM cell has estimated that an amount of Rs 776 crore may be required to fund the entire capital expenditure for implementing all the components of the MSW Rules.

It can be inferred from recent developments in states that some states have become proactive in extending technical and financial support to ULBs to implement the rules. However, in spite of support from state governments, many local bodies are at a loss to identify appropriate technologies for treatment and disposal of waste. They are not aware of merits and demerits of each technology advocated by the vendors. Without past experience and technical expertise, several local bodies end up with facilities, which neither fully meet the statutory requirements nor are they suitable under local conditions.

PPP in Cities

Bangalore

Bangalore has entered into two kinds of service contracts. One for the primary waste collection from the doorstep and transportation to the disposal site through small contractors and another for integrated treatment and disposal of waste through payment of tipping fees to expert agencies.

In the first kind of arrangement, 66 per cent of the city has been divided into 61 groups and contracts are given for

primary waste collection in waste tricycles/handcarts and direct transfer to a vehicle (owned by the contractor) and transportation to the disposal site. Each contractor manages 2 to 3 health wards of the city at the maximum. With this arrangement, the ULB is now spending 50 per cent of what it would cost to undertake the task departmentally.

In another contract for the treatment and disposal of 1000 mt of waste per day, land and solid waste is to be given by the MCB to the private operator who is expected to make an investment of about Rs 25 to 30 crore to set up the facility. The corporation is not expected to pay for waste treatment but a tipping fee of Rs 195 per MT of rejects is agreed upon. A maximum limit of 30 per cent of waste delivered for treatment has been set to ensure that minimum waste comes to the engineered landfill for disposal.

Chennai

Chennai is the pioneer in PPPs for SWM on a large scale. The municipal corporation has withdrawn its staff from the three out of the ten zones of the city. A seven-year contract has been awarded to the private operator Onyx through a transparent competitive bidding process for primary collection, street sweeping, secondary storage at a transfer station and transportation of waste to the disposal site. Onyx has engaged its own manpower, tools, equipment and fleet of vehicles. It is paid on a Rs per tonne basis with an annual increase of 5 per cent in this rate built into the contract. The cost per tonne of waste in this arrangement is merely 50 per cent of the departmental cost for the same service provided by the city administration in the other zones. The efficiency of service has gone up and the quantity of waste collected has increased substantially. Unfortunately, segregation of recyclable waste at source in terms of MSW Rules 2000 is not a part of the contract. Motivational efforts by the Municipal Commissioner have resulted in successful source segregation and door-to-door collection in the zones directly managed by the municipality.

Hyderabad

Hyderabad has privatized nearly 75 per cent of its street sweeping operations applying a unique unit area method to eliminate the bidding process. Each unit comprising of 8 km road length is allotted to a team of 15 female and 3 male workers for street sweeping and waste transfer to the secondary storage depot. The unit cost has been worked out on the basis of the need for manpower, the minimum wage payable, the tools and equipment required, etc. It comes to Rs 48,853 per month per 18 sanitation workers for cleaning during the day and Rs 69,250 per month per 18 sanitation workers for night cleaning. Applications are invited and contracts awarded through drawing of lots. One unit area is allotted to each contractor who in turn hires sanitation workers. One hundred and sixty-one such contracts are in place engaging 4347 workers in sweeping of streets, footpaths, and open spaces during the day and 2015 workers for sweeping 310 km important roads at night. This includes 14 self-employed women groups. The system is in operation for more than five years and working satisfactorily.

Selco International is running a WTE facility using RDF technology in Hyderabad in consultation with TIFAC to produce 200 tonnes RDF per day from 700 tonnes of municipal solid waste provided by the municipality free of charge. The municipal corporation has provided 10 acres land on 30 years lease to Selco with an annual lease rent of 5 per cent of the registered value of the land. Selco has been further allowed to mortgage the leasehold land in favour of financial institutions. Starting with an RDF plant using up to 400 MT of MSW initially, Selco has recently set up an RDF based power plant of 6.6 MW capacity at Shadnagar, 55 km from Hyderabad. The fluff prepared at the RDF plant is transported to the power plant where it is used along with 30 per cent agro-waste for generating power. The plant is functional since November 2003. It is expected that this plant will reduce greenhouse gas emission equivalent to 43,705 MT of carbon dioxide per year.

Ahmedabad

PPPs in SWM in Ahmedabad started with the setting up of a 500 MT capacity compost plant. This was followed by private contracting of secondary storage and transportation. Door-to-door collection of waste is now entirely conducted through RWAs, associations of sanitation workers, and women's organizations. The municipal corporation gives grants for door-to-door waste collection, and its supervision. It has met with reasonable success in all its SWM ventures through PPPs.

For primary collection of waste, the city is divided into 3900 units of 200 households each. Each unit is allotted to an RWA and in its absence, other associations of backward classes and women. In the first year of its operation, the corporation has decided to provide a grant to the concerned association at the rate of Rs 10 per family per month. The corporation has provided containerized tricycles costing Rs 6500 each to the sanitation workers appointed by the RWA with the future arrangements of replacing the same at regular intervals. The sanitation workers are expected to visit each house and collect MSW in their containerized tricycle and deposit the waste at the municipal waste depot. The corporation proposes to introduce a user fee to recover the cost from the citizens after demonstrating for one year, the benefits of doorstep collection. Corporation is likely to club it along with property tax under a separate account. The commercial areas

are proposed to be similarly covered but without any payment to the waste collector. Here, the amount of Rs 10 per month per shop is proposed to be recovered directly from the shopkeeper by the waste collector.

The work of supervision of door-to-door collection has been contracted out to the All India Institute of Local Self Government (AIILSG) with the working arrangement that the sanitation diploma holders who qualify from the institute would be posted for one year field training cum service to the city government which would pay part of the trainee's stipend.

The municipal corporation has privatized 50 per cent of secondary waste storage and transportation. About 300 waste storage depots in the city have been handed over to two private entrepreneurs. Secondary storage bins of 7 cubic metre capacity placed all over the city receive waste through sanitation workers. These containers once filled are transported to the treatment plant or disposal site using vehicles and manpower engaged by the private contractor.

In the area of waste treatment, Excel Industries Ltd has set up a mechanized compost plant on 25 acres of municipal land allotted at a nominal lease rent of Re 1 per square metre per year for a period of 15 years. In return for 500 MT of waste provided free of cost at the plant site, the corporation expects to receive Rs 35 per MT of compost produced as a royalty. The plant is operational since 2001. The responsibility of operation and maintenance of the facility as well as marketing of the product rests with Excel Industries. The plant is functioning at 50–60 per cent of installed capacity due to problems in marketing the compost.

Surat

Surat—the second largest city of Gujarat with a population of 2.4 million—used to be one of the dirtiest cities of India. The city introduced several measures of privatization in solid waste management after the plague in 1994, which transformed it to one among the cleanest.

Unlike other cities Surat practises night brushing and scraping of roads. Forty-seven major roads have been identified for night cleaning by 1183 persons and 99 vehicles deployed through 31 agencies. 30 paise per sq mt is paid for night cleaning amounting to an annual expenditure of Rs 472 lakh resulting in annual saving of Rs 30 lakh.

Privately managed primary waste collection has been introduced in some parts of the city. Four hundred residential societies have been given grant in aid at the rate of 40 paise per sq mt per month for cleaning their own area. Minimum amount of Rs 1000 is given per society. One sweeper is engaged per 3000 sq mt by the society.

Two hundred and forty hotels and restaurants are being serviced through the hotel association engaging 42 workers and 18 vehicles for collection and transportation of hotel waste.

Transportation of waste from the primary collection points to transfer stations has been contracted to two agencies who deploy 22 vehicles to make a total 221 trips per day. Rs 128 per trip is paid to the contractor resulting in a net saving of 17.40 per cent in transportation cost.

Contracts for secondary transportation of waste for removing MSW from transfer station to final disposal site have been awarded to four private agencies. Five transfer stations have been set up and the entire quantity of 1000 MT of MSW is transported by the private agencies at the rate of Rs 7.81 per kmMT. The contractors deploy 42 close body vehicles, which make 150 daily trips.

For final waste disposal Surat has constructed the first large size engineered landfill in the country with a cell capacity of 12,5000 cmt through a private agency at a cost of Rs 105 per cmt. The cost of the cell constructed is Rs 131 lakh, which will last for six years. Provision of seven more cells is made for the future.

For disposal of biomedical waste, a seven-year contract has been awarded to a private operator on BOOT basis. A plant with the capacity to dispose 200 kg of waste per day has been constructed. It is equipped with an incinerator, autoclave, and shredder. Rs 10 per kg is charged for collection, transportation, and disposal of biomedical waste. Three hundred and fifty-six hospitals with 5087 beds, 1154 dispensaries and 157 pathological laboratories are served through 27 collection centres.

North Dumdum and New Barrackpore Municipalities

Both these cities have taken up a model SWM demonstration project with 50 per cent cost sharing by government of India through the Central Pollution Control Board. Both the cities have introduced an element of cost recovery for primary collection of waste from the doorstep to make the operation sustainable.

North Dumdum Municipality with population of over 2 lakh has awarded contracts to unemployed youth. The waste collectors are allotted about 250 to 300 houses each for door-to-door collection using a containerized tricycle and a whistle. Their supervisor, who is also on contract, collects the user fees at the rate of Rs 10 from every household. The user fee is shared among sanitation workers (Rs 8), supervisors (Re 1) and municipality (Re 1). The extent of cost recovery is around 95 per cent. The system is working very well.

The city of New Barrackpore is relatively small with a population of about 85,000. Here too door-to-door collection of waste is privately managed. The monthly charge prescribed is only Rs 5 per family per month and is directly recovered by the sanitation worker from the beneficiary. The percentage of recovery is almost 100 per cent.

Cities are evolving various ways to handle solid waste. The Municipal Corporation of Delhi has invested funds into

integrated reform of its SWM system to ensure a clean city (Box 8.3). Some cities, on the other hand, are making improvements in their existing facilities. Nagpur has converted their waste dumpsite into a model municipal landfill site (Box 8.4).

Issues related to PPP in SWM

Labour Issues—Contract Labour (Regulation and Abolition) Act, 1970 (CLA)

This Act was passed in 1970 when the government was concerned about exploitation of workers under the contract labour system. The Act abolished contract labour in various jobs and processes and regulated its employment where it could not be abolished. It essentially lays down the relationship between the principal employer and contract labour.

In accordance with provisions laid out under Section 10 (1) of the CLA, the state governments may prohibit employment of contract labour in any process, operation or work in any establishment (defined to include any office or department of a local authority). Any state that chooses to exercise this provision must carefully review implications of such a decision on the delivery of SWM service, staff strength and related expenditure of the local body. Further such a ban would preclude private sector participation. Tamil Nadu has banned the use of contract labour in sweeping and scavenging services. The Chennai Municipal Corporation had to request the state for special exemption from the ban to privatize SWM services.

It may be noted that in case a local body chooses to employ contract labour for SWM, it would be the principal employer and the onus of fulfilling the terms under the CLA would rest with it. In case a contract is awarded to a private operator, the local body as the principal employer must ensure that the private firm meets duties under the CLA. Alternately, the local body must specify/identify the private firm as the principal employer in the project agreement.

If a private firm takes up the job of collecting household waste and transporting the same either to the municipal dust bin or up to the designated dumping sites as per an agreement reached with individual households or residential associations, the said activities cannot be taken as done at the instance of the local body and it cannot be taken as the principal employer.

The Supreme Court of India has interpreted this law and set the matter to rest in Special C.A. No. 6009–6010 of 2001 in Steel Authority of India Limited and others versus National Union, Water Front Workers and others which must be carefully studied by municipal authorities.

Environmental issues

a. Siting: Siting of a landfill facility is very difficult task and meets with stiff resistance from the community living nearby as well as by vested interests operating in that area. The MSW rules for siting must be adhered to in order to minimize adverse impact on environment and quality of life of citizens. A number of PILs have been filed in recent years regarding the siting of waste treatment and disposal facilities. Such PILs delay project implementation and have financial implications for the private firm.

b. Adherence to Environmental Standards: Since treatment and disposal of municipal solid waste poses problems of the environmental pollution and health hazards, the private operators as well as municipal authorities are expected to be very careful. The Pollution Control Boards are duty bound to ensure that MSW is managed properly as per terms of MSW Rules 2000. The treatment and disposal facilities can face closure if the standards are not met.

Patents issues

In the case of patented technology/process, the issue of patent transfer needs to be reviewed. This may become critical for local bodies to be able to successfully operate and maintain such facilities upon transfer.

Role of Informal Sector: NGOs and CBOs

Whereas the private sector can play an important role in construction, operation, and maintenance of treatment and disposal facility, NGOs can play an important role in:

- organizing rag-pickers/waste collectors for door-to-door collection and segregation of waste
- creating public awareness for storage of organic and recyclable waste separately at source and handing over the waste to the waste collector.
- promoting recycling of waste and decentralized treatment of waste involving community, CBOs, etc.

Rag-pickers could be involved in door-to-door collection of municipal solid waste as well as recyclable waste so that they could get a user fee for collecting waste from the doorstep and derive additional income from sale of recyclables. There is a potential of recovering at least 15 per cent of the waste generated in the country which could be more than 15,000 MT per day providing employment opportunities to about 5,00,000 rag-pickers in the country. Despite immense potential in big cities in this area, NGO/CBO participation is still on a very small scale.

The Self-Employed Women's Association (SEWA) has taken up the task of door-to-door waste collection in Vejalpur and Gandhinagar cities near Ahmedabad and providing employment to over 500 rag-pickers. Similarly, the Centre for Development Communication in Jaipur has taken up the work of primary collection and transportation of waste

Box 8.3

Integrated Reforms at the Municipal Corporation of Delhi

Shubhagato Dasgupta

The Municipal Corporation of Delhi is among the largest municipal bodies in the world providing civic services to more than 13.78 million citizens (2001) in the capital city. It is next only to Tokyo in terms of area under its jurisdiction. Also within its jurisdiction are some of the most densely populated areas in the world. The Conservancy and Sanitary Engineering Department (CSE) of MCD caters to 94 per cent of the area of Delhi state, serving a population of more than 13 million. The per capita garbage generation is estimated to be 0.45 kg per day amounting to 6500 MT per day for the city. Currently, the actual garbage lifting per day is 6000 MT. The projected garbage generation by 2021 is 18,000 MT per day. CSE department has a staff strength of between 60,000–70,000 persons consisting mainly of sweepers.

Undoubtedly the task of MSWM in Delhi is a daunting one and in spite of massive daily expenditure on service provision, there remains a significant need for upgradation. The failure of the MCD to provide quality services complying with MoEF Rules in a timely, aesthetic, and hygienic fashion to the citizens' satisfaction within the city's budget constraints raises serious issues that demand attention. While health concerns of the sanitation workers led to the mechanization and modernization of collection and transportation operations, the city faces a limitation of disposal sites.

To tackle these key concerns a comprehensive strategy, strongly driven by the Commissioner, was developed after detailed discussions with the CSE personnel. The overall upgradation strategy to create an integrated efficient and effective garbage collection, transfer and disposal system in Delhi was designed in three phases: (a) collection, segregation, and transportation through PPP, (b) a technical master plan for disposal and (c) private sector based treatment and disposal projects based on recommendations of the Master plan. The MCD with other agencies developed the parameters for project development including technical and financial viability studies. The first two phases were started simultaneously while the final phase is expected to commence towards the end of phase II. United Nations Office for Project Services (UNOPS) funds were raised for the waste treatment and disposal master plan for the state of Delhi for the next 25 years.

In the first phase a 'Public Private Partnership in Collection and Transportation of Municipal Solid Waste in 6 MCD Zones' was initiated with the following key features

1. Six of the 12 zones selected for the projects were—City Zone, S. P. Zone, K. B. Zone, South Zone, West Zone, and Central Zone.
2. An open competitive bidding process was used to select the private operator. The six zones were organized into two zone sets and bidders qualified for one zone set were barred from applying for another zone set. Final proposals were received from three bidders each in the two zone sets.
3. The contractual framework on a Design, Procure, Renovate, Operate, Maintain, and Transfer (DPROMT) basis was set in place through a Concession Agreement.

Some important developments have resulted:

1. *New standards of service*: The new contracts were designed to provide higher levels of service than currently available. This included daily clearance of biodegradable waste; containerization from community bins onwards through the transport chain and mechanized lifting of waste.
2. *Segregation and segregated transportation of waste*: The contract also specifies a segregation benchmark, which the transporter has to achieve year on year. The segregation benchmark, which allows for a low level in the first year of operations steadily builds up over a five year period. Elaborate arrangements have been conceived of to test the segregation levels achieved at the disposal site. Strong incentives and penalties have been built in to ensure that the transporter achieves the segregation benchmark.
3. *Tipping fee and long term contract*: The contract envisages a 9 years exclusive concession, which is based on a tipping fee payable by MCD on a per tonne basis. This was developed out of the typical depreciation period for vehicles as well as on a risk mitigation strategy based on which the private sector is expected to take all design and financing risks associated to the project.
4. *Independent performance monitoring* has been built into the contract with detailed schedules for performance measurement linked to a strong set of incentives for improving levels of service and penalties and cancellation of the contract for non-performance.
5. *Independent regulation*: a specific mandate to an independent consultant to review environmental compliance is directly related to performance evaluation of the private operator.
6. *Dispute resolution*: a committee of private operators is envisaged which will be responsible to benchmark the performance in each zone and will be the first stop to work out disputes with the MCD.

This contract was very successful in the market and 6 bidders' submitted proposals. Finally four were selected and operations are expected to start up shortly. The bid price is also expected to provide immense savings to MCD as most of the awards have been at levels which are approximately half the expenses incurred in an MCD run system despite significantly upgraded service levels. The Master Plan for Treatment and Disposal has been finalized for MCD and planning for implementation is being currently worked out with the support of IDFC and IL&FS.

Note: Views expressed here are of the author of the box.

Box 8.4
Sanitary Landfill at Nagpur

Nutan Zarapkar

Nagpur city generates approximately 564 tonnes of municipal solid waste per day which has been dumped for the last 30 years at the Bhandewadi dumpsite located about 12 km east of Nagpur. It is estimated that 30–40 per cent of the waste consists of organic material. The site is spread over an area of 22 hectares with waste distributed at heights ranging from 1 to 2.5 metres.

USAEP/USAID through its western region offices provided the Nagpur Municipal Corporation (NMC) technical assistance to develop this site as a 'Model Municipal Landfill Site'. The technical Assistance (TA) study carried out by National Productivity Council and AIILSG on the existing dumpsite revealed that the waste was spread unevenly over the entire area and almost seventy per cent waste was accumulated on the eastern side. It was therefore recommended that the existing solid waste be accumulated on one side of the dumpsite and then that area be scientifically closed. The remaining area could then be utilized to develop a model sanitary landfill for receiving new loads of solid waste.

Consequently, the NMC is now implementing a US$230,000 project to close the existing dumpsite. This project envisages the screening, sifting, and encapsulating of the waste. The waste mound will be provided with appropriate lining for leacheate control and gas vents to capture the methane generated. The gas collected will either be used for generating heat/power or flared dependent on techno-economic viability.

The present status of the project is as under.

1. Environmental assessment studies have been completed for ground and surface water contamination in the surrounding area, waste characterization etc.
2. Design and plan for upgradation has been prepared. Waste shifting, levelling and compaction in the identified area is underway to form the waste heap. About 70 per cent of the work is complete. Subsequently, the waste heap would be closed scientifically as per the MSW Rules 2000.
3. Design and plan for the sanitary landfill in the cleared area has been completed. The pre-qualification process for awarding contracts has been completed. About six agencies have been short-listed. A detailed tender document has been prepared, which will be issued to these six agencies shortly.

Note: Views expressed here are of the author of the box.

involving half a dozen cities covering population of over a million. Exnora which initially introduced the concept of door-to-door collection on cost recovery basis in India has been playing an important role in Chennai and Bangalore in door-to-door collection of waste with community participation. Sustainability of this service can be ensured through user charges levied on beneficiary households, shops, and establishments.

Funds Required for SWM

To improve SWM services in urban areas the Supreme Court Appointed committee had estimated a cost of Rs 1.5 crore per 100,000 population in 1999. This includes collection, transportation, processing and disposal of waste in a scientific manner. This amounts to a total expenditure of Rs 4275 crore consisting of Rs 1710 crore spent on vehicles, tools, equipment, and Rs 2565 crore for the treatment and disposal.

The Ministry of Urban Development appointed an expert committee which wrote the manual on solid waste management, has given standard cost estimates as under for modernization of solid waste management practices in various categories of cities and towns in India (Table 8.9).

Given the financial position of the municipal authorities central and state government assistance is imperative for SWM service improvement.

The urban development ministry formulated a waste management scheme for class I cities/towns indicating a need of nearly Rs 2500 crore and posed it to the 12th Finance Commission for devolution of funds to ULBs. Public–private partnerships have been suggested by the ministry as integral part of the scheme in order to leverage funds and add efficiencies.

It is essential that the operating and maintenance costs be carefully assessed. SWM collection equipment has a short-life and operating and maintenance costs are substantial.

Table 8.9
Estimated Cost for Vehicle, Tools, Equipments and Composting

City population (in million)	Cost of vehicles, tools and equipment (in Rs lakh)	Cost of composting (Rs lakh)
<0.1	50.97	20
0.1–<0.5	295.00	150
0.5–<1.0	511.00	500
>2.0	948.00	1000

Operations and maintenance costs is generally obtained from two sources: current general revenues and SWM operating revenue, essentially user charges.

Operational Expenditure

SWM constitutes up to 10 to 50 per cent of municipal budget expenditure depending on the income sources of the municipal authorities. The main expenditure heads under SWM are in salaries and allowances, consumables, vehicles repair and maintenance, contingencies and others. A recent survey by the National Institute of Urban Affairs shows 'salaries of sanitation workers' for SWM in class I cities, constitute as much as 75 per cent of total SWM expenditure. This is still higher at 85 per cent in class II cities.

Capital Investments

Capital costs for SWM in India are met from the current revenue and borrowings. City level planning with related budget estimates, is usually absent in most local bodies. Cities borrow funds from financial institutions such as HUDCO and banks for financing equipment and vehicles to the extent their financial health permits.

Sources of Funds

Conservancy Tax

Traditionally, funding for solid waste systems comes from the general fund. Most ULBs use a percentage of the property tax to support the solid waste management system. This tax, known as conservancy tax, is easy to administer since no separate billing or collection system is needed. However, the disadvantage is that in most Indian cities' assessment and collection of property tax is poor and this poor base provides for very little income.

User Charges

Increased public awareness of solid waste issues and public involvement in the decision-making process may provide the opportunity to adjust user charges to reflect real costs of providing solid waste services.

User charges if properly administered:

- are an equitable means of funding SWM services;
- can provide incentive to reduce waste generation; and encourage recycling.

Revenue from Recovery and Treatment of Waste

Waste recycling, composting, waste-to-energy, may generate operating revenues or at least reduce the cost of treatment of waste. Such programmes provide tangible financial benefits from recovered materials and conserved energy, and additional benefits from avoided costs of land filling. Further, these help increase the life of a landfill facility.

Investment by the Private Sector

Role of the private sector in financing resource recovery (composting, waste-to-energy) facilities is growing in India. Many composting facilities and two power plants have been set up in the country with private sector participation.

Pool Financing Mechanism

Under this arrangement local bodies can come together to develop/construct common facilities on a cost sharing basis and access the capital market to raise funds for such projects through a common lead agency that must be established by the state government.

Supplementing ULB Resources

The 12th Finance Commission Grants

The 12th Finance Commission has taken a very considered view for improving urban infrastructure and allotted Rs 5000 crore for supplementing the resources of the ULBs in the country (Table 8.10).

Out of above amount, 50 per cent amount has been earmarked for improving SWM services. This is the first time a sizeable allocation has been made towards SWM by the government. This amount is to be spent between 2005–10. The urban renewal fund of the government also has an SWM component. If the state governments and ULBs come forward with matching funds, effective management of MSW should be possible.

Support from State Governments

Uttar Pradesh, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Maharashtra, Haryana, Karnataka, Gujarat, and Rajasthan have announced policy measures pertaining to allotment of land at nominal lease rent, free supply of garbage and facilities for evacuation, sale and purchase of power to encourage the setting up of WTE projects. The tariff for power purchase is agreed upon as per the general guidelines issued by the Ministry of Non-Conventional Energy Sources (MNES). However, there are often delays in finalization of actual contract terms with the entrepreneur, especially with regard to power tariff, in the wake of the deregulation of the power sector and the absence of clear policy direction.

Table 8.10
12th Finance Allocation to Municipalities and Panchayats (2005–10)

S.no.	State	Panchayats		Municipalities	
		per cent	(Rs crore)	per cent	(Rs crore)
1.	Andhra Pradesh	7.935	1587.00	7.480	374.00
2.	Arunachal Pradesh	0.340	68.00	0.060	3.00
3.	Assam	2.630	526.00	1.100	55.00
4.	Bihar	8.120	1624.00	2.840	142.00
5.	Chhattisgarh	3.075	615.00	1.760	88.00
6.	Goa	0.090	18.00	0.240	12.00
7.	Gujarat	4.655	931.00	8.280	414.00
8.	Haryana	1.940	388.00	1.820	91.00
9.	Himachal Pradesh	0.735	147.00	0.160	8.00
10.	Jammu and Kashmir	1.405	281.00	0.760	38.00
11.	Jharkhand	2.410	482.00	1.960	98.00
12.	Karnataka	4.440	888.00	6.460	323.00
13.	Kerala	4.925	985.00	2.980	149.00
14.	Madhya Pradesh	8.315	1663.00	7.220	361.00
15.	Maharashtra	9.915	1983.00	15.820	791.00
16.	Manipur	0.230	46.00	0.180	9.00
17.	Meghalaya	0.250	50.00	0.160	8.00
18.	Mizoram	0.100	20.00	0.200	10.00
19.	Nagaland	0.200	40.00	0.120	6.00
20.	Orissa	4.015	803.00	2.080	104.00
21.	Punjab	1.620	324.00	3.420	171.00
22.	Rajasthan	6.150	1230.00	4.400	220.00
23.	Sikkim	0.065	13.00	0.020	1.00
24.	Tamil Nadu	4.350	870.00	11.440	572.00
25.	Tripura	0.285	57.00	0.160	8.00
26.	Uttar Pradesh	14.640	2928.00	10.340	517.00
27.	Uttaranchal	0.810	162.00	0.680	34.00
28.	West Bengal	6.355	1271.00	7.860	393.00
	Total	100.000	20000.00	100.000	5000.00

Subsidy for Compost Plants and WTE Projects

The Ministry of Agriculture (MoA) and the Ministry of Environment and Forest (MoEF) have been actively promoting waste composting, while the MNES has designed schemes to promote WTE projects. Further the Ministry of Environment and Forests had also sanctioned a project to the Central Road Research Institute for conducting research on effective utilization of MSW in road construction.

The MoA and the MoEF have two separate schemes to promote MSW composting. Both schemes provide only subsidies without follow-up on implementation and performance monitoring. As a result the impact of these schemes is not known readily at the GOI level.

The MoA introduced a centrally sponsored 'Balanced and Integrated Use of Fertilizers' in 1992 (Eighth five-year plan period 1992–7), under which support is given to local bodies and private sector (included recently) for setting up compost plants using MSW. This grant is available for building plant, and machinery up to one-third of the project cost subject to a maximum of Rs 50 lakh per project for a treatment capacity of 50 to 100 TPD. Thirty-eight projects were taken up under this scheme. The total central assistance proposed during the Ninth plan period (1997–2002) was Rs 180 million and the budget provision during the 2002–3 was Rs 5 crore. The grant remains largely unutilized.

Since 1992 the MOEF has been providing financial subsidies of up to 50 per cent of the capital costs to set up demonstration plants on MSW composting. The ministry also extends limited financial assistance for waste characterization and feasibility studies. The MoEF sanctioned 3 pilot projects for qualitative and quantitative assessment of the solid waste in the cities of Hyderabad, Simla, and Ghaziabad.

Recently a few more demonstration projects have been sanctioned and they are under implementation in North Dumdum and New Barrackpore municipalities in West Bengal, Chandigarh, Kozikode in Kerala, and Udumalpet in Tamil Nadu. Three more projects of Kohima, Suryapet and Mandi are likely to be sanctioned shortly.

The National Programme on energy recovery from urban and industrial waste was launched by the MNES during the year 1995 with the approval of the Commission for Additional Sources of Energy (CASE). MNES has notified an accelerated programme providing financial assistance for projects on energy recovery from urban waste during the year 2005–6. The incentives offered vary from scheme to scheme (Table 8.11).

For projects in the North Eastern Region and special category states namely, Himachal Pradesh, J&K, Sikkim and Uttaranchal financial assistance will be 20 per cent higher than those specified. The Supreme Court of India has, however, ordered the government of India not to sanction any subsidies for projects based on municipal solid waste until further orders of the Supreme Court. Therefore, government of India subsidies for waste to energy projects are on hold at the moment. This is mainly because issues have been raised before the Court about the misuse of the provisions made and the matter is under judicial scrutiny.

Funds from Sale of Carbon Credits

Major international initiatives are underway to mitigate greenhouse gas emission (GHG). Rio-Earth summit 1992

Table 8.11
GOI Subsidy on SWM Plants

Project for power generation from MSW involving refuse derived fuel (RDF)	Rs 1.5 crore per MW
Power project based on high rate bio-methanation technology	Rs 2 crore per MW
Demonstration project for power generation from MSW based on gasification/Pyrolysis and plasma arc technology	Rs 3 crore per MW
Biomethanation technology for power generation from cattle dung, vegetable market and slaughterhouse waste above 250 KW capacity	50 per cent of project cost up to a maximum of Rs 3 crore per MW
Bio-gas generation for thermal application	Up to Rs 1 crore per MW equivalent
Project development assistance	Up to Rs 10 lakh per project
Training course, seminar, workshop, etc.	Rs 3 lakh per event

Note: The financial assistance for any single project will be limited to Rs 8 crore.
Source: Government of India, Ministry of Non-Conventional Energy Source Scheme, 25 July 2005.

focused attention on this issue and it was further strengthened at Kyoto in 1997 wherein industrialized nations agreed to reduce their aggregate emission to 5.2 per cent of 1990 levels by 2008–12. As reduction of emission invites huge costs for developed nations, they have evolved an ingenious system where in they can reduce emissions in any part of the world and earn carbon credits to count towards their effort to reduce greenhouse gas emissions globally. There are three mechanisms to supplement the national effort to achieve measurable and cost effective GHG reduction as under.

1. Clean development mechanism (CDM)
2. International emission trading (IET)
3. Joint implementation (JI)

Cities can take up waste treatment and disposal projects under this mechanism and avail of the benefits through sale of certified emission reduction credits at the prevailing market price (ranging from US$6 to US$9 per tonne carbon equivalent) to the developed countries through well established mechanism involving consultants dealing with this matter. The MoEF has a nodal officer handling these matters. Landfills generate biogas consisting of 50 per cent methane. A tonne of methane is equivalent to 21 tonnes of carbon dioxide and a serious threat to the cause of GHG reduction. Appropriately management of landfills, compost plants or WTE plants can earn municipal authorities in large cities substantial carbon credits which can be sold not only to recover cost of system installation and upgradation of operations but also generate surplus funds invaluable for the cash starved ULBs. Smaller cities can pool resources together and make a combined case for availing of carbon credits.

Way Forward

While SWM was completely neglected in past and is now receiving some attention at the highest levels in several cities and states, many are lagging behind and several have not bothered to make any improvement at all. The national and state solid waste management missions need to be created to ensure that municipal authorities perform their obligatory duties regularly in compliance with MSW Rules 2000 within a predetermined time frame.

The financial allocation of the government of India as per the 12th Finance Commission recommendations, the urban renewal fund, and state level allocations for SWM need to be pooled judiciously and used in a planned manner through the national and state missions. ULBs need to be strengthened with handholding wherever necessary to meet the challenge.

More specific steps could include the following:

1. The national mission, in consultation with state missions, could prepare strategies to implement Municipal Solid Waste (Management & Handling) Rules 2000 in time bound manner.
2. The national mission should include a nation-wide awareness campaign through media using expert communication agencies seeking community participation in solid waste management. State missions should give wide publicity to conducive solid waste management practices to attract community, NGO and private sector participation.
3. The national and state missions could identify, empanel and circulate lists of national and international experts, individuals, and organizations, to provide technical know how as well as commercial SWM services to the ULBs. These firms could, construct and operationalize treatment and disposal facilities, take up O & M contracts, etc.
4. The national mission, in consultation with state missions, could prepare tender documents, designs and specifications, and concession agreements to facilitate expeditious procurement of tools, vehicles, and services.
5. It could dovetail programmes of various ministries responsible for different aspects of solid waste management with the activities of national and state missions. Ministries involved would include Ministry of Environment and Forests, Ministry of Urban Development, Ministry of Health and Family Welfare, Ministry of Agriculture, and Ministry of Non Conventional Energy Sources.
6. To market compost produced through SWM activities, the mission should include a programme to promote its use as compost amongst farmers raising awareness about its advantages over chemical fertilizers in preserving the

fertility of the soil while leading to productivity increases. Linking the subsidy on chemical fertilizers with the use of compost could introduce an incentive into the system.

7. State level task forces under respective district magistrates/ collectors could be given a timeline of 6 months to identify suitable sites for treatment and disposal of waste within the parameters of the MSW Rules 2000 for cities and towns falling in their jurisdiction.
8. All states should appoint an Empowered Committee for the allotment of government land for treatment and disposal of waste free of cost. Local bodies as well as regional planning authorities like the District Planning Committee and Metropolitan Planning Committees, Improvement Trusts, and Urban Development Authorities should make adequate provisions of appropriate land for setting up temporary waste store depots in each city and for setting up treatment plants and sanitary landfill sites in land-use plans keeping in mind requirements projected for the next 25 years.
9. Common cost sharing facilities could be created on large parcels of land for groups of cities, which could be professionally managed for shared benefits.
10. A state policy could be formulated to ensure that government and semi-government parks, gardens and farmlands give preference to the use of compost produced by ULBs within the state.

Though levels of SWM services in the country have started improving on account of active monitoring by the Supreme Court of India, the central and state pollution control boards and finance and technical support from proactive state governments there still is a long way to go. Save the formalization of the MSW Rules 2000, state action in this regard at many levels has been fairly uninspiring thus far. While MSW Rules 2000 is a watershed document in India's history of effective SWM, implementation issues still overwhelm the system. A firm commitment from central and the state governments towards a time bound mission to turn the provisions into action is urgent. Isolated cases of short-term steps to manage solid waste can hardly be cited as instances of governmental awareness and sensitivity to a problem that is only getting more daunting with each passing hour. It is no longer enough to take ad hoc measures to merely postpone the inevitable consequences of decades of neglect and nationwide mismanagement of SWM. A comprehensive nationwide programme needs to be actively implemented keeping in mind possible future scenarios. Key individuals within the governing system and the bureaucracy need to be educated to the magnitude of the crisis and motivated to use their power to influence the system and appropriately channelize resources to actively promote effective and progressive SWM projects and practices.

ANNEXE

Table A8.1
Waste Generation Rates in Developing Countries

S.no.	Country	Current urban MSW generation (kg/capita/day)
	Low income	0.64
1.	Nepal	0.50
2.	Bangladesh	0.49
3.	Myanmar	0.45
4.	Vietnam	0.55
5.	Mongolia	0.60
6.	India	0.46
7.	Lao PDR	0.69
8.	China	0.79
9.	Sri Lanka	0.89
	Middle income	0.73
1.	Indonesia	0.76
2.	Philippines	0.52
3.	Thailand	1.10
4.	Malaysia	0.81
	High income	1.64
1.	Korea, Republic of	1.59
2.	Hong Kong	5.07
3.	Singapore	1.10
4.	Japan	1.47

Source: World Bank (1997a)

Table A8.2
Per Capita Solid Waste Generation in Developed Nations

Country	MSW generation rate kg/capita/day
USA	2.00
Japan	1.12
Germany	0.99
Mexico	0.85
France	1.29
Turkey	1.09
Italy	0.96
Canada	1.80
Spain	0.99
Poland	0.93
Australia	1.89
The Netherlands	1.37
Belgium	1.10
Hungary	1.07
Austria	1.18
Greece	0.85
Portugal	0.90
Sweden	1.01
Finland	1.70
Switzerland	1.10
Denmark	1.26
Norway	1.40

Source: OECD (1995), World Bank (1997b)

Table A8.3
Physical Characteristics of Municipal Solid Waste in Indian Cities

Population range (in millions)	No. of cities surveyed	Paper	Rubber, leather and synthetics	Glass	Metal	Total compo-stable matter	Inert material
0.1 to 0.5	12	2.91	0.78	0.56	0.33	44.57	43.59
0.5 to 1.0	15	2.95	0.73	0.56	0.32	40.04	48.38
1.0 to 2.0	09	4.71	0.71	0.46	0.49	38.95	44.73
2.0 to 5.0	03	3.18	0.48	0.48	0.59	56.67	40.07
5.0 and above	04	6.43	0.28	0.94	0.80	30.84	53.90

Note: All values are in per cent calculated on wet weight basis.
Source: NEERI (1995)

Table A8.4
Physical Composition of Municipal Solid Waste in 1 million plus Cities and State Capitals in India (average values)

		Recyclables				Others including inert						Total
Name of the city	Total compostable	Paper, etc.	Plastic	Glass	Metal	Inert	Rubber and leather	Rags	Wooden matter	Coconut	Bones	
Indore	48.97	6.10	5.77	0.55	0.15	31.02	2.95	2.41	1.17	0.91	0.00	100
Bhopal	52.44	9.01	12.38	0.55	0.39	18.88	0.09	2.65	1.35	2.25	0.01	100
Dhanbad	46.93	7.20	5.56	1.79	1.62	26.93	2.77	4.14	1.56	1.52	0.00	100
Jabalpur	48.07	7.67	8.30	0.35	0.29	26.60	2.15	4.42	1.49	0.66	0.00	100
Jamshedpur	43.36	10.24	5.27	0.06	0.13	30.93	2.51	2.99	4.29	0.22	0.01	100
Patna	51.96	4.78	4.14	2.00	1.66	25.47	1.17	4.17	1.43	2.34	0.89	100
Ranchi	51.49	3.17	3.45	1.79	1.45	25.92	1.45	4.97	2.74	3.19	0.38	100
Bhubaneshwar	49.81	5.74	5.70	0.46	0.79	27.15	2.10	3.21	2.85	2.20	0.00	100
Ahmedabad	40.81	5.28	5.29	0.79	0.30	39.28	0.92	5.00	1.22	1.02	0.10	100
Nashik	39.52	9.69	12.58	1.30	1.54	27.12	1.11	2.53	0.34	4.12	0.15	100
Raipur	51.40	8.31	7.07	0.76	0.16	16.97	1.47	3.90	1.43	6.44	0.08	100
Asansol	50.33	10.66	2.78	0.77	0.00	25.49	0.48	3.05	3.00	2.49	0.95	100
Bangalore	51.84	11.58	9.72	0.78	0.35	17.34	1.14	2.29	2.67	2.28	0.01	100
Agartala	58.57	8.11	4.43	0.98	0.16	20.57	0.76	2.17	0.00	2.56	1.69	100
Agra	46.38	6.12	8.72	0.85	0.11	30.07	1.97	3.92	1.68	0.19	0.00	100
Allahabad	35.49	7.27	10.33	1.23	0.40	31.01	1.83	7.34	2.08	2.74	0.30	100
Daman	29.60	10.54	8.92	2.15	0.410	34.80	2.60	4.90	1.60	4.48	–	100
Faridabad	42.06	8.57	13.73	0.83	0.18	26.52	2.52	4.14	1.26	0.19	–	100
Lucknow	47.41	6.87	7.45	0.92	0.29	18.01	5.38	9.48	2.10	2.09	0.00	100
Meerut	54.54	4.95	54.48	0.30	0.24	27.30	0.49	4.98	0.95	0.66	0.12	100
Nagpur	47.41	6.87	7.45	0.92	0.29	18.01	5.38	9.48	2.10	2.09	–	100
Vadodara	47.43	5.98	7.58	0.47	0.47	27.80	1.28	4.86	1.55	2.58	–	100
Gandhinagar	34.30	5.60	6.40	0.80	0.40	36.50	3.70	5.30	3.70	3.30	–	100
Visakhapatanam	45.96	14.46	9.24	0.35	0.15	20.77	0.47	2.41	0.68	5.51	–	100
Dehradun	51.37	9.56	8.58	1.40	0.03	22.89	0.23	5.60	0.32	–	–	100
Ludhiana	49.80	9.65	8.27	1.03	0.37	17.57	1.01	11.50	0.80	0.00	–	100
Guwahati	53.69	11.63	10.04	1.30	0.31	17.66	0.16	2.18	1.39	1.38	0.26	100
Kohima	57.48	12.28	6.80	2.32	1.26	15.97	0.18	1.86	1.70	0.00	0.35	100

Note: Increasing use of plastics is changing the composition of municipal solid waste and causing harm in the processing of waste. The use of plastics has increased 70 times between 1960 and 1995.
Source: CPCB (2000)

Table A8.5
Composition of Solid Waste in Developing Countries

	Compostable	Paper	Plastic	Glass	Metal	Others
Low income countries	41	4.6	3.8	2.1	1	47.5
Nepal	80	7	2.5	3	0.5	7
Bangladesh	84.37	5.68	1.74	3.19	3.19	1.83
Myanmar	80	4	2	0	0	14
India	41.8	5.7	3.9	2.1	1.9	44.6
Lao PDR	54.3	3.3	7.8	8.5	3.8	22.3
China	35.8	3.7	3.8	2	0.3	54.4
Sri Lanka	76.4	10.6	5.7	1.3	1.3	4.7
Middle income	57.5	14.9	10.9	2.4	3.1	11.2
Indonesia	70.2	10.6	8.7	1.7	1.8	7
Philippines	41.6	19.5	13.8	2.5	4.8	17.8
Thailand	48.6	14.6	13.9	5.1	3.6	14.2
Malaysia	43.2	23.7	11.2	3.2	4.2	14.5
High income	27.8	36	9.4	6.7	7.7	12.4
Hong Kong	37.2	21.6	15.7	3.9	3.9	17.7
Singapore	44.4	28.3	11.8	4.1	4.1	6.6
Japan	22	45	9	7	6	11

Source: World Bank (1999)

Table A8.6
Physical composition of MSW in Developed Countries

Country	Organic	Paper	Plastic	Glass	Metal	Other
Canada	34	28	11	7	8	13
Mexico	52	14	4	6	3	20
USA	23	38	9	7	8	16
Japan	26	46	9	7	8	12
Australia	50	22	7	9	5	8
Denmark	37	30	7	6	3	17
Finland	32	26	0	6	3	35
France	25	30	10	12	6	17
Greece	49	20	9	5	5	13
Luxembourg	44	20	8	7	3	17
Netherlands	43	27	9	4	5	8
Norway	18	31	6	4	5	36
Portugal	35	23	12	5	3	22
Spain	44	21	11	7	4	13
Switzerland	27	28	15	3	3	24
Turkey	64	6	3	2	1	24
Average	38	26	8	6	5	18

Note: Composition of waste varies with the size of the city, season and income group.
Source: OECD (1995)

Table A8.7
Chemical Characteristics of Municipal Solid Waste in Indian Cities

Population range (in million)	Nitrogen as total Nitrogen	Phosphorous as P_2O_5	Potassium as K_2O	C/N Ratio	Calorific Value kcal/kg.
0.1 to 0.5	0.71	0.63	0.83	30.94	1009.89
0.5 to 1.0	0.66	0.56	0.69	21.13	900.61
1.0 to 2.0	0.64	0.82	0.72	23.68	980.05
2.0 to 5.0	0.56	0.69	0.78	22.45	907.18
5.0 and above	0.56	0.52	0.52	30.11	800.70

Source: NEERI (1995)

Table A8.8
Chemical Characteristics of Municipal Solid Waste plus (Average Values) of 1 million plus Cities and State Capitals.

Name of city	Moisture	ph Range	Volatile matter	C per cent	N per cent	P per cent as P_2O_5	K per cent as K_2O	c/n ratio	hcv Kcal/ kg
Indore	30.87	6.37–9.73	38.02	21.99	0.82	0.61	0.71	29.30	1436.75
Bhopal	42.66	6.99–9.03	35.78	23.53	0.94	0.66	0.51	21.58	1421.32
Dhanbad	50.28	7.11–8.01	16.52	9.08	0.54	0.55	0.44	18.22	590.56
Jabalpur	34.56	5.84–10.94	46.60	25.17	0.96	0.60	1.04	27.28	2051
Jamshedpur	47.61	6.20–8.26	24.43	13.59	0.69	0.54	0.51	19.29	1008.84
Patna	35.95	7.42–8.62	24.72	14.32	0.77	0.77	0.64	18.39	818.82
Ranchi	48.69	6.96–8.02	29.70	17.20	0.85	0.61	0.79	20.37	1059.59
Bhubaneshwar	59.26	6.41–7.62	25.84	15.02	0.73	0.64	0.67	20.66	741.56
Ahmedabad	32	6.2–8.0	63.80	37.02	1.18	0.67	0.42	34.61	1180
Nashik	74.64	5.2–7.0	59	34.22	0.92	0.49	–	38.17	3086.51
Raipur	29.49	6.65–7.99	32.15	18.64	0.82	0.67	0.72	23.50	1273.17
Asansol	54.48	6.44–8.22	17.73	10.07	0.79	0.76	0.54	14.08	1156.07
Bangalore	54.95	6.0–7.7	48.28	27.98	0.80	0.54	1.00	35.12	2385.96
Agartala	60,.06	5.21–7.65	49.52	28.82	9.96	0.53	0.77	30.02	2427
Agra	28.33	6.21–8.1	18.90	10.96	0.52	0.60	0.57	21.56	519.82
Allahabad	18.40	7.13	29.51	17.12	0.88	0.73	0.70	19.00	1180.12
Daman	52.78	5.88–6.61	52.99	30.74	1.38	0.47	0.6	22.34	2588
Faridabad	34.02	6.33–8.25	25.72	14.92	0.80	0.62	0.66	18.58	1319.02
Lucknow	59.87	4.8–9.18	34.04	20.32	0.93	0.65	0.79	21.41	1556.78
Meerut	32.48	6.16–7.95	26.67	15.47	0.79	0.80	1.02	19.24	1088.65
Nagpur	40.55	4.91–7.80	57.10	33.12	1.24	0.71	1.46	26.37	2632.23
Vadodara	24.98	–	34.96	20.28	0.60	0.71	0.38	40.34	1780.51
Gandhinagar	23.69	7.02	44	25.5	0.79	0.62	0.39	36.05	698.02
Visakhapatanam	52.70	7.5–8.7	64.4	37.3	0.97	0.66	1.10	41.70	1602.09
Dehradun	79.36	6.12–7.24	39.81	23.08	1.24	0.91	3.64	25.90	2445.47
Ludhiana	64.59	5.21–7.40	43.66	25.32	0.91	0.56	3.08	52.17	2559.19
Guwahati	70.93	6.41–7.72	34.27	19.88	1.10	0.76	1.06	17.71	1519.49
Kohima	64.93	5.63–7.7	57.20	33.17	1.09	0.73	0.97	30.87	2844

Source: Akolkar (2005)

Table A8.9
Composting Plants in India

No.	State	City	Facility manufacturer	Installed capacity
1.	Andhra Pradesh	Vijayawada	Excel Industries Ltd	125 TPD
2.		Thirumala	NA	NA
3.		Vizianagaram	NA	NA
4.	Assam	Kamarup	NA	NA
5.	Chhatisgarh	Dhamtari	NA	NA
6.		Rajnandgaon	NA	NA
7.		Jagdalpur	NA	NA
8.		Rakpur	NA	NA
9.		Korba	NA	NA
10.		Bhilai	NA	NA
11.		Durg	NA	NA
12.		Raigad	NA	NA
13.	Delhi (UT)	Delhi	Nature And Waste Inc India (BALSWA Plant)	500 TPD
14.		Delhi	Private Organo-PSOS Plant, (Tikri Plant)	150 TPD
15.		Delhi	MCD Plant, Okla	300 TPD
16.		Delhi	NDMC Plant, Okla	300 TPD
17.	Gujarat	Ahmedabad	Excel Industries Ltd, Ahmedabad	500 TPD
18.		Junagadh	NA	NA
19.		Rajkot	NA	NA
20.	Goa	Margao	M/s. Comets International Ltd	40 TPD
21.	Himachal Pradesh	Shimla	L&T	100 TPD
22.		Solan	Janseva Trust	50 TPD
23.		Sirmour	NA	NA
24.		Dharamshala	NA	NA
25.		Bilaspur	NA	NA
26.		Una	NA	NA
27.		Hamirpur	NA	NA
28.		Kangra	NA	NA
29.		Kullu	NA	NA
30.		Mandi	NA	NA
31.	Karnataka	Bangalore	Karnataka Compost Development Corporation	350 TPD
32.		Bangalore	Terra-Fersia Bio-Technologies Ltd	100 TPD
33.		Mysore	Vennar Organic Fertilizer Pvt. Ltd	200 TPD
34.		Mangalore	NA	NA
35.	Kerala	Thiruvananthapuram	POABS Envirotech Pvt. Ltd	300 TPD
36.		Kozhikode	NA	300 TPD
37.		Adoor	NA	NA
38.		Atingal	NA	NA
39.		Chalakundy	NA	NA
40.	Madhya Pradesh	Bhopal	M. P. State Agro Industries	100 TPD
41.		Gwalior	NA	120 TPD
42.	Maharashtra	Nasik	M/s. Live Biotech	300 TPD
43.		Aurangabad	M/s. Satyam Bio-fertilizer Co. Ltd	300 TPD
44.		Thane	M/s. Leaf Biotech Ltd	300 TPD
45.	Meghalaya	Shillong	M/s. Anderson Biotech Pvt. Ltd	150 TPD
46.	Orissa	Puri	M/s. Krishi Rashyan, Kolkata	100 TPD
47.	Pondicherry	Pondicherry	Pondicherry Agro Services and Industries	100 TPD
48.	Tamil Nadu	Tiruppur	IVR Enviro Project (P) Ltd	100 TPD
49.		Nagercoil	NA	NA
50.	West Bengal	Kolkata	M/s. Eastern Organic Fertilizer P. Ltd	700 TPD

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